AGRICULTURAL ENGINEERING

SEPTEMBER • 1951

The Economic Evaluation of Farm Tractor Fuels — *Wayne H. Worthington*

Engineering Problems in Soil and Water Conservation — *Louis P. Merrill*

Progress of Cotton Mechanization in California — *J. R. Tavernetti and B. B. Ewing*

Some New Data on Resistance of Grains to Air Flow — *Claude K. Shedd*

Some Engineering Aspects of Electric Traps for Insects — *J. G. Taylor, H. O. Deay, M. T. Orem*

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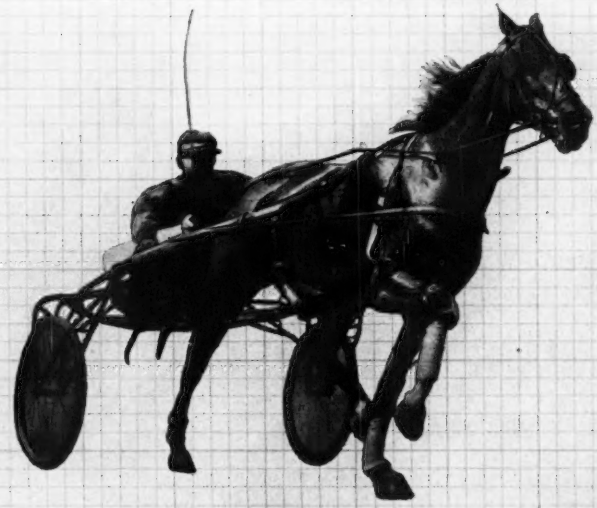

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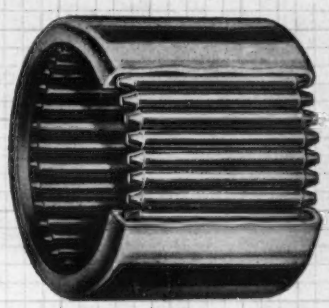

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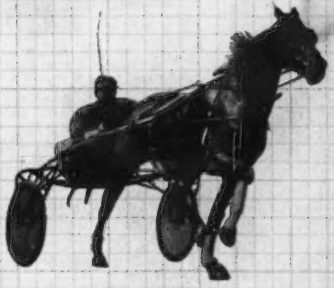

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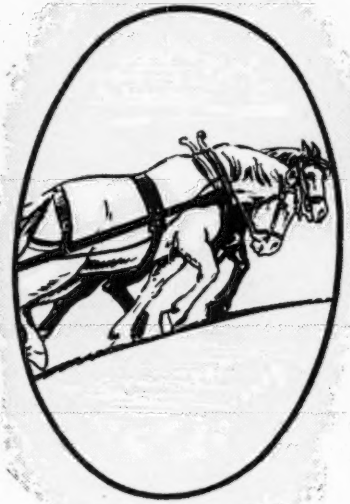

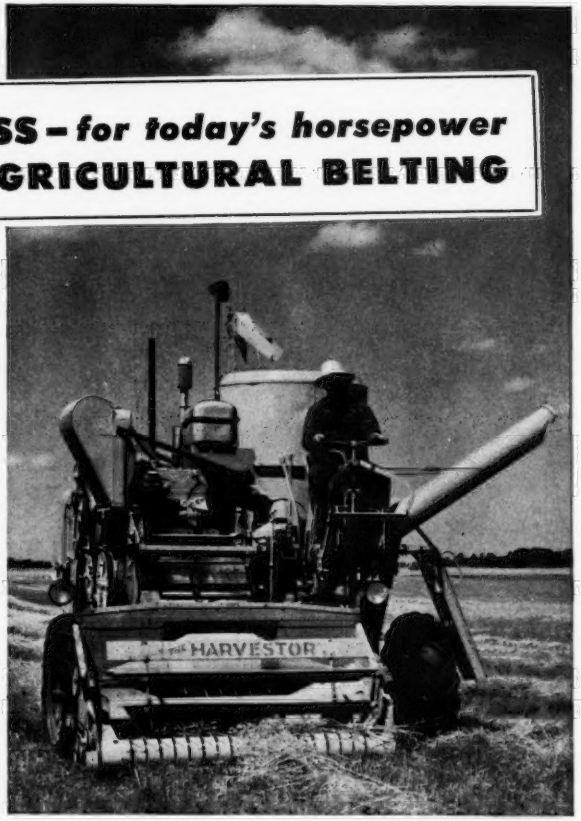

Since the days when Dobbin reigned supreme, horsepower has had to be harnessed. Modern machine horsepower requires the "harness" of engineered rubber belts. For example, the self-propelled HARVESTOR shown here uses several Manhattan Agricultural Belts to harness its power to the many drives that perform its intricate operations of combine harvesting. There must be no excessive stretch or slip on a machine like this to affect critical speeds between synchronized shafts.

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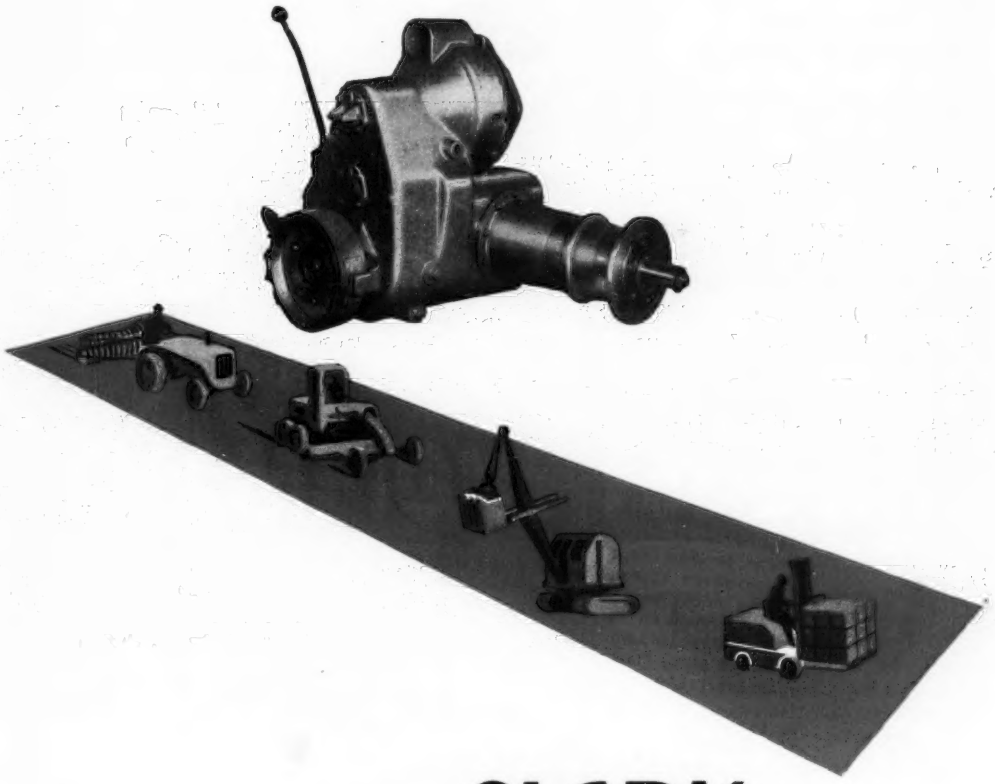

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ALUMINUM GOES TO SCHOOL -

Reynolds Farm Institute begins a series of research projects and field tests.

A primary purpose of Reynolds Farm Institute is to provide reliable and unbiased information through cooperative research projects with agricultural colleges and universities. These projects are set up as cooperative ventures designed to bring together the knowledge of manufacturers and research institutions to obtain facts relating to the advantages of aluminum in any specific use or application.

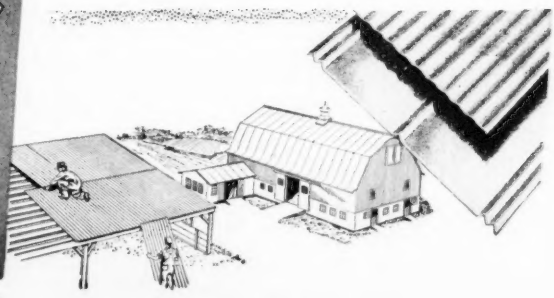
Most of the experiments concern the effect of aluminum's radiant heat reflectivity on livestock and poultry production. Shade research on animal shelters continues in areas where intense heat retards production. Aluminum dairy barns are being studied in regions where climatic conditions dictate variations of construction and management. In the field of poultry, where aluminum has already proved an important aid to production, tests are continuing in principal poultry producing areas. Increased interest in better rural housing prompts Farm Institute research in this important field.

The benefit of summer heat reduction in aluminum structures is also being tested for grain storage. The converse of this — winter heat retention, and consequent fuel saving — is being proved in tobacco-curing tests, using aluminum-lined structures. Fruit growing is another category on the planned list — testing aluminum for picking sheds and for its insulating value in storage.

The benefits indicated by these projects are entirely apart from the structural advantages of light, strong aluminum, and the reduction in building maintenance cost through aluminum's rust-proof permanence. Reports will be made as test results are recorded.

REYNOLDS FARM INSTITUTE

These areas are covered by active Farm Institute projects.



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"On my 360-acre farm I spend a lot of time on my tractors, and I know just about what I have to have in tires to get my work done. Maybe my soil is different, but it seems to me that Firestone Open-Center Tires pull better than any of the others."
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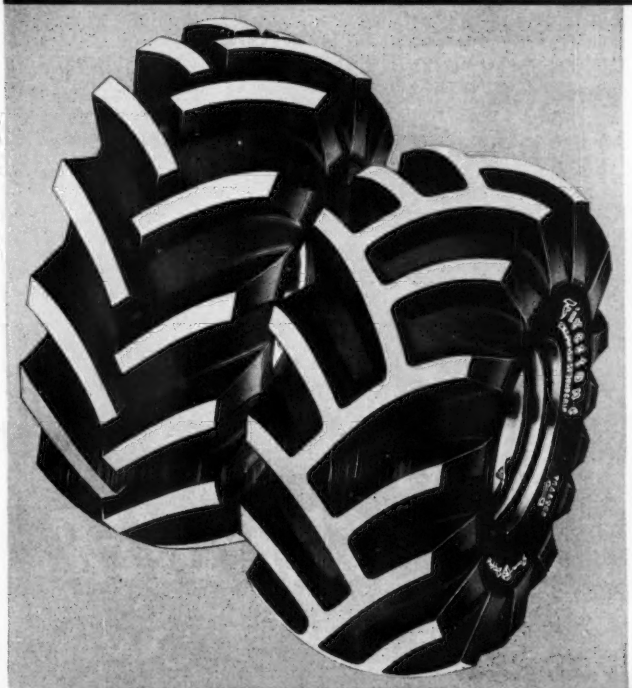
CHAMPIONS For Both



THAT'S the way it is in most farming localities — Some farmers want Open-Center Tires, while others find that Traction-Centers do a better job in their soil conditions. In all probability, you have a definite preference, too.

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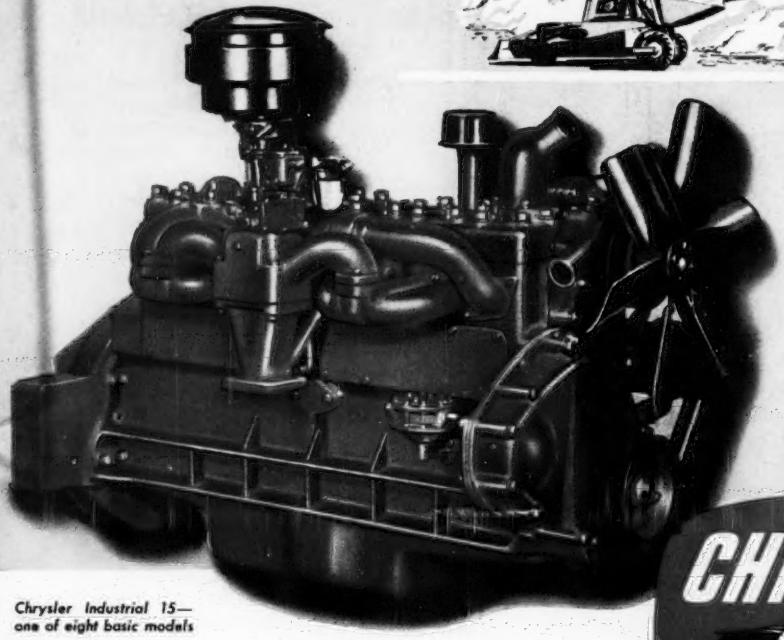

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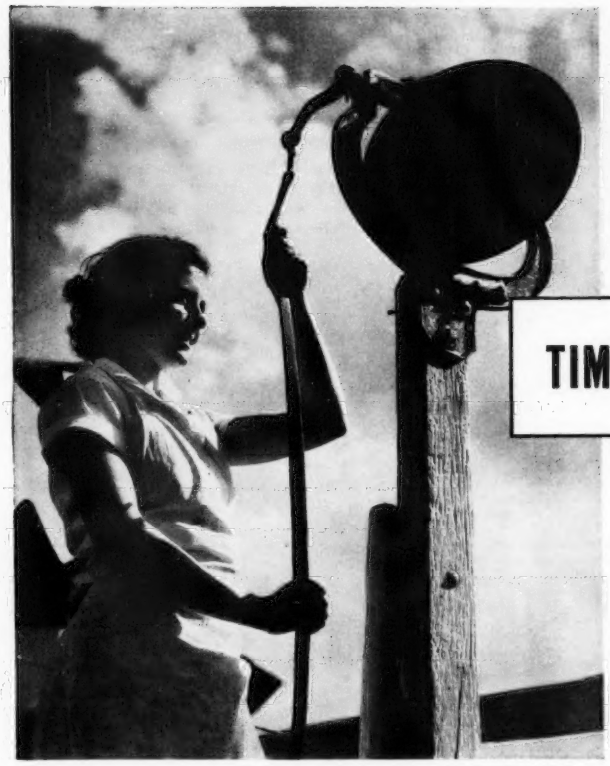

TIME OUT, OLD-TIMERS

The hills have yet to echo sweeter sound than the ringing "come and get it" of the old dinner bell, splitting a torrid day in two at threshing time. For the busy crew, it meant a well-earned pause—the first since sunup. It meant a brief "time out," a chance to stretch a bit—and get out from under a morning's layer of chaff and dust and sweat. But best of all it meant a sumptuous feast—the kind reserved for kings and threshermen—the **very best** of a talented kitchen crew, garnished with the humor and good-natured banter that signal real fellowship.

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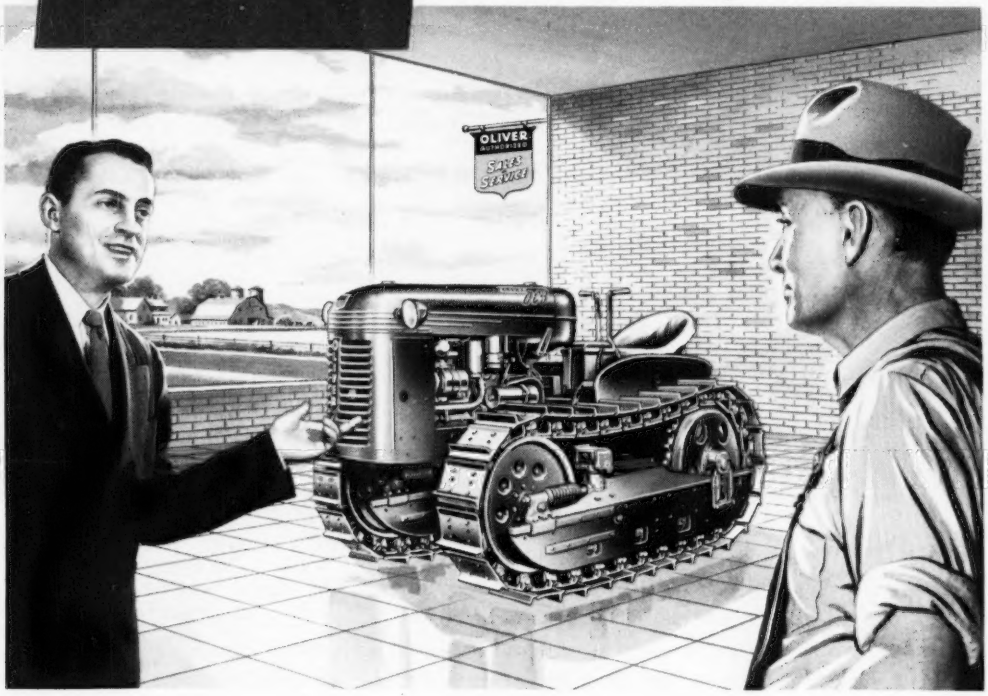

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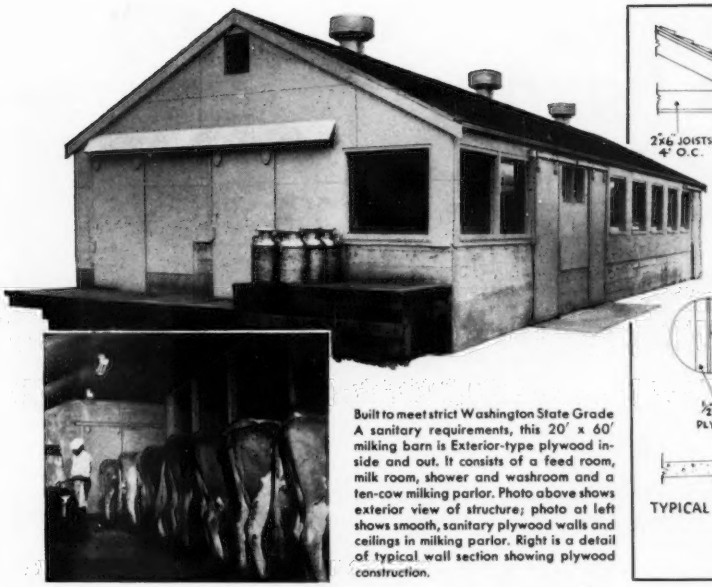

Built to meet strict Washington State Grade A sanitary requirements, this 20' x 60' milking barn is Exterior-type plywood inside and out. It consists of a feed room, milk room, shower and washroom and a ten-cow milking parlor. Photo above shows exterior view of structure; photo at left shows smooth, sanitary plywood walls and ceilings in milking parlor. Right is a detail of typical wall section showing plywood construction.

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An informative booklet, Washington State College Extension Bulletin No. 410 "Approved Milking Parlors," is available free. Write Douglas Fir Plywood Association for your copy. See address below.

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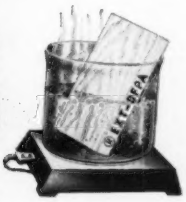

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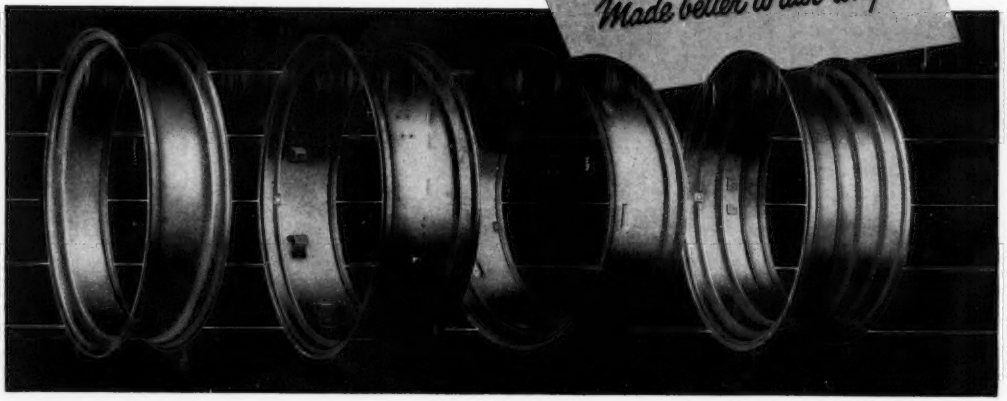

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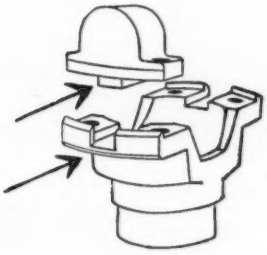
The only function of the cap screws is to hold the bearing assemblies in place.

This KEY method of driving has the highest safety factor, transmits the most rorque with the least weight, and avoids costly breakdowns resulting from driving through bolts or screws that work loose.



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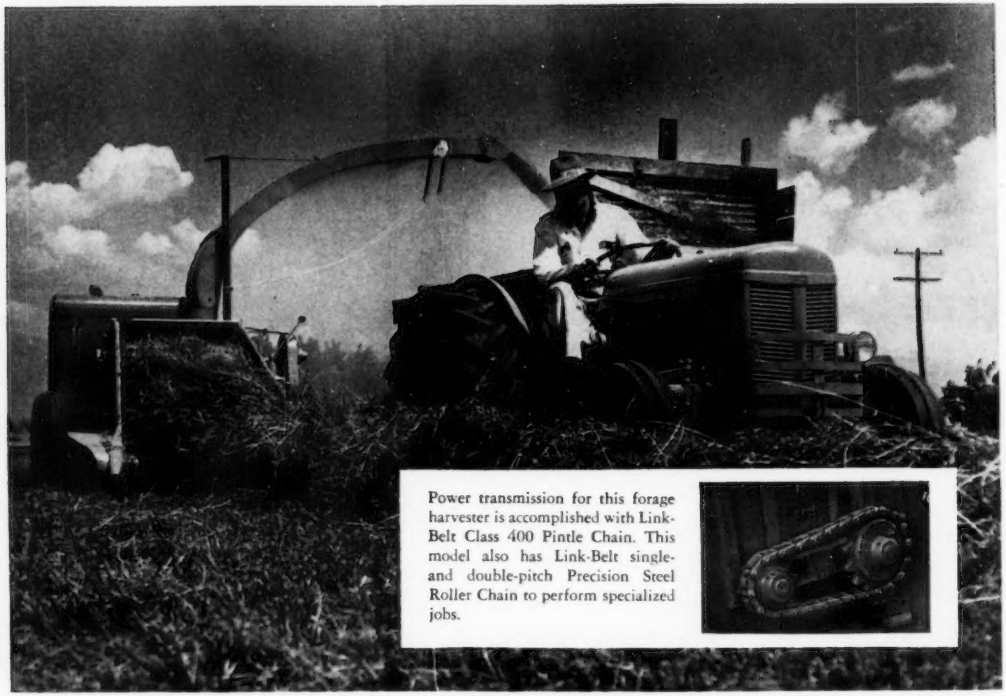

Power transmission for this forage harvester is accomplished with Link-Belt Class 400 Pintle Chain. This model also has Link-Belt single- and double-pitch Precision Steel Roller Chain to perform specialized jobs.

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CHAINS AND SPROCKETS

EDITORIAL

The Teachers' Mission

MOST of our older readers know Fred A. Wirt (past-president of ASAE) as a former teacher of agricultural engineering, who in recent years has extended his teaching to wider audiences and broader aspects of the encouragement and utilization of technology in the American way of life.

In June he addressed the agricultural engineering section of the American Society for Engineering Education on the subject "The Role of Power Farming in National Defense." His closing words included four recommendations to today's agricultural engineering teachers, which we believe worthy of special note:

"1.....the more students know about the design, construction, operation, maintenance, and uses of farm power and machines, the better such equipment can be utilized in producing food, feed, and fiber.

"2.....all agricultural students — certainly all agricultural engineering students — should have this broad understanding of the great contribution of farm machinery to the country's welfare, so that they might disseminate this fundamental truth wherever they work or travel.

"3.....farm machinery courses must include information on how tractors, plows, and other farm machines can be used to carry out practices necessary to the conservation of soil and water.

"4.....instruction in the climate of freedom under which the farm machinery industry developed and the farmers of this country turned first from hand methods to machine methods, and later to power farming methods, is vitally important to agricultural engineering courses."

Mr. Wirt has said, in effect, that the defense emergency emphasizes the importance of sound teaching by agricultural engineers. A more general public appreciation of the role of power farming in national defense is important. The point that agricultural engineers render an especially valuable service in connection with the improvement, maintenance, and effective utilization of farm equipment is one too often overlooked, even in some sections of the farm equipment industry. Defense requirements emphasize the importance of strong engineering leaders as well as sound technicians. Encouraging professional students to think in terms of the human environment and purposes, as well as the physical, to which agricultural engineering is applied, is a start toward the development of a new generation of leaders.

Agricultural engineering teachers have a long-range mission important to the further development of our civilization. When they may have occasion to feel that the importance of their work is poorly appreciated, they may well ascribe it to the fact that many of the rest of us are fully and narrowly preoccupied with short-range objectives.

Engineering Requirements in Farm Structures

AGRICULTURAL engineers in the farm structures field have been led to a measure of constructive self-criticism.

W. G. Kaiser (past-president ASAE) emphasized an apparently unsatisfactory situation in his contribution to a panel discussion on employment requirements of agricultural engineers at the ASAE annual meeting in June. Based on his own long experience and supporting statements from other leaders in the farm building materials industry, he indicated that most agricultural-engineering graduates specialized in farm structures need further training along four lines in order to work effectively as agricultural engineers in the industry.

These four lines are structural design, materials of construction, mechanical equipment and utilities used in farm structures, and public speaking.

It is significant that these are comments, not from outsiders but from leaders in the industry, employers and potential employers of agricultural engineers, and men who are themselves in some cases agricultural engineering graduates.

They are not expressions of mere wishful thinking, but conclusions based on comparisons between considerable numbers of men trained in agricultural, civil, architectural, structural, and other branches of engineering. They represent a challenge from the farm building materials industry to the college agricultural engineering departments.

It will not be easy to meet that challenge. Obstacles to tailoring curriculums to the satisfaction of individual employers and employing industries are well known. Possibly as much improvement may be gained by reshaping instruction in individual courses within an accredited curriculum as by juggling the whole curriculum.

On the face of it, the challenge is one to be met determinedly. The improvement of structures from the standpoint of serving farm functions is patently a matter of agricultural engineering. Presumably the development of men specially qualified for work in this field should be a responsibility of the college agricultural engineering departments, whatever the specific nature of the curriculum content.

If we understand them correctly, the men in the industry are saying they would like to be able to hire agricultural engineering graduates with sound foundations in architectural and structural engineering rather than architectural or structural engineers having some slight incidental knowledge of modern agriculture.

Opportunities in Sprinkler Irrigation

OCCASIONALLY an engineering development proves so popular as to temporarily outrun the engineering needed for its most effective application. That appears to be the case currently in sprinkler irrigation.

There simply aren't enough engineers to keep up with the demand for new installations. As a result, individually sound power supplies, pumps, pipes and sprinkler heads not well matched to each other, to the available water supply, or to the job to be done on a particular farm, are being combined without benefit of engineering, into systems which will give something less than optimum satisfaction.

In some cases the systems thus thrown together may work well enough to represent a net gain, and to keep the farmer interested in their continued use and improvement. Sooner or later these farmers will get the engineering help they need to realize the full profit possibilities of irrigation practice. Their loss, the difference between a profit and the greater profit they might have made, is the lesser of two evils.

In some other cases aggregations of equipment items brought together without benefit of engineering will not result in systems that can show any profit. The result will be a loss to the farmer, dissatisfaction, and an unjustified setback to irrigation practice, irrigation engineers, and the manufacturers of irrigation equipment.

The equipment manufacturers, dealers, irrigation engineers, and college agricultural engineering departments are awake to the problem. Manufacturers are asking the colleges to offer courses in sprinkler irrigation engineering which will help to qualify graduates for beginning work in this field. That should help, to the extent that students can be interested in careers in irrigation engineering.

It must be remembered that irrigation engineering is only one of many fields in which there is a strong demand for additional highly trained men. Technology has given us some things that we like, and an appetite for more of them. It has given us a realization that we can have them only by acceptance of a more complex life. It is a life in which larger number of our people must apply their energies and intelligence to the further development and application of new knowledge and higher skills. The work of one engineer creates opportunity for another. *(Continued on page 476)*

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AGRICULTURAL ENGINEERING

VOL. 32 SEPTEMBER, 1951 No. 9

The Economic Evaluation of Farm Tractor Fuels

By Wayne H. Worthington

MEMBER ASAE

FIRST job of the product engineer is to thoroughly understand operating costs and then to provide products reflecting lower costs. The *greatest single factor* determining cost of power farming, which today largely includes all farm work on the American scene, is the overall cost of tractor power. In order that power costs may be intelligently evaluated, a procedure has been developed for analyzing tractor operating expense and is presented here in the hope that it may be of value to those who design, sell, service, and use power-farming equipment.

The cost of tractor fuel is direct out-of-pocket expense to the user and is generally the major item of operating cost. The availability and cost of tractor fuels is constantly changing, and any tractor manufacturer who consistently lives up to a policy of building tractors suitable for efficient and economical utilization of all fuels generally available is not unlike the cat which, when thrown up in the air, always lights on its feet. The progress of the Deere organization in engineering better fuel utilization, particularly of low cost fuels, is shown in Table 1, which is a summary of fuel consumption results secured during official Nebraska 10-hr rated drawbar tests from 1920 on.

Two important points of interest are in evidence in Table 1. First, when gasoline having controlled octane values became available, suitable high-compression engines were provided which reduced the specific fuel consumption to a point where the use of gasoline became popular. This is true because the advantages from the use of gasoline outweigh the somewhat greater cost of fuel. Second, as the price of distillate increased (due largely to the fact that it was no longer a by-product or a "distress" fuel), the diesel combustion cycle was developed to a point where fuel costs reached a new low.

The diesel engine is not only highly economical in its use of fuel at full load, but has the characteristic, so compatible with the varying load conditions of farm service, of remaining economical at lighter loads. This advantage is particularly evident when compared with throttle-governed, spark-ignition engines. This is shown in Fig. 1, where the performance of gasoline, all-fuel, and diesel engines are compared on the common denomination of operating maximum horsepower.

Since all tractors operate most efficiently when doing work requiring approximately 75 per cent or more of their maximum power, the importance of matching the job to the tractor power cannot be too strongly emphasized. The effects of tractor size and type on fuel cost are evaluated in Fig. 2.

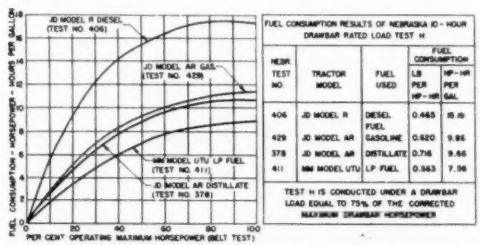
Changing conditions, such as the widespread use of catalytic refining processes, the phenomenal increase in domestic oil heating — resulting in no small measure from artificial restrictions on the availability of coal — and requirements for controlled-ignition characteristics (minimum octane value), all operated to increase the cost of distillate as a tractor fuel and largely eliminate distillate-burning tractors from the scene. This in turn brought about the widespread use of "regular" gasoline (of controlled-ignition characteristics) in lighter tractors, particularly those intended for general-purpose operations and accelerated the use of diesel engines in larger tractors.

More recently, LP gas (liquified petroleum gas), otherwise known as "natural gasoline," has become increasingly available, constituting a growing fraction of our total petroleum supply, of which it is a part. The pattern of growth in the production of natural gas liquids is shown in Fig. 3. The end uses of these products is shown in Fig. 4. It will be seen that the expanding use of these products has only recently begun to taper off, which probably accounts for the great volume of propaganda in promoting the use of LP gas for farm tractors. The reduced usage throughout the United States of LP gas fuel in internal-combustion engines in 1949 as compared with 1948 is shown in Fig. 5. These data, based on official U.S. Bureau of Mines reports, are quite contrary to the expressions of those promoting the sale of such fuels.

The historical price pattern of representative tractor fuels over the last decade is charted in Fig. 6. This shows that from 1940 through 1948 the prices of LP gas followed the pattern of other liquid fuels; but that since that time, it would appear that price was determined largely by "distress" conditions. The present spread in prices at the refinery, e.g., 2¢ per gal at Bartlesville, Okla., to 7¢ per gal at Bayonne, N. J., evidences the erratic nature of the price structure. It is the considered opinion of a great segment of the petroleum industry that,

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Power and Machinery Division.

The author: WAYNE H. WORTHINGTON, director of engineering research, John Deere Waterloo Tractor Works of Deere Mfg. Co., Waterloo, Iowa.


JD MODEL R DIESEL (TEST NO. 406)
JD MODEL AR GAS. (TEST NO. 429)
MM MODEL UTU LP FUEL (TEST NO. 411)
JD MODEL AR DISTILLATE (TEST NO. 378)
FUEL CONSUMPTION - HORSEPOWER - HOURS PER GALLON
PER CENT OPERATING MAXIMUM HORSEPOWER (BELT TEST)

FUEL CONSUMPTION RESULTS OF NEBRASKA 10-HOUR DRAWBAR RATED LOAD TEST H

NEBR. TEST NO.	TRACTOR MODEL	FUEL USED	FUEL CONSUMPTION LB PER HP-HR	FUEL CONSUMPTION HP-HR PER GAL
406	JD MODEL R	DIESEL FUEL	0.465	15.19
429	JD MODEL AR	GASOLINE	0.620	9.86
378	JD MODEL AR	DISTILLATE	0.716	9.66
411	MM MODEL UTU	LP FUEL	0.563	7.96

TEST H IS CONDUCTED UNDER A DRAWBAR LOAD EQUAL TO 75% OF THE CORRECTED MAXIMUM DRAWBAR HORSEPOWER

Fig. 1 Engine performance (Nebraska Test E)

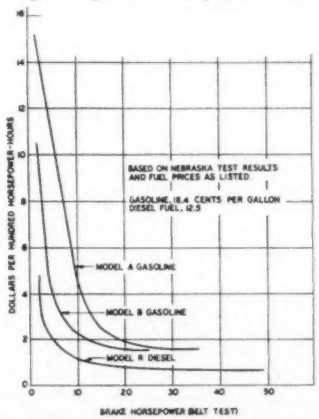

BASED ON NEBRASKA TEST RESULTS AND FUEL PRICES AS LISTED
GASOLINE, 18.4 CENTS PER GALLON
DIESEL FUEL, 12.5
MODEL A GASOLINE
MODEL B GASOLINE
MODEL R DIESEL
DOLLARS PER HUNDRED HORSEPOWER-HOURS
BRAKE HORSEPOWER (BELT TEST)

Fig. 2 Effect of engine size and type on fuel cost

TABLE 1. ANALYSIS OF FUEL CONSUMPTION RESULTS SECURED DURING OFFICIAL NEBRASKA TEN-HOUR RATED LOAD TEST

Year	Nebraska test number	John Deere tractor model	Dhp-hr per gal of fuel	Wheel equipment	Fuel used	Approx. price* of fuel used during Nebr. test, c/gal	Approx. price* of reg. grade gasoline c/gal	Cost per 100 dhp-hr based on fuel used in Nebr. test
1920	1	N	4.23	Steel	Kerosene	12.5	21.0	$2.95
1924	102	D	6.18	Steel	Kerosene	12.2	16.2	1.97
1927	146	D	6.69	Steel	Kerosene	12.3	14.0	1.84
1935	236	D	7.33	Steel	Distillate	8.2	12.2	1.12
1940	350	D	8.78	Rubber	Distillate	8.9	12.4	1.01
1941	378	All-Fuel	9.66	Rubber	Distillate	9.1	12.9	0.94
1949†	——	All-Fuel	9.66	Rubber	Tractor fuel	15.4	18.4	1.59
1949	429	AR Gasoline	9.86	Rubber	Reg. gasoline	18.4	18.4	1.87
1949	406	R	15.19	Rubber	Diesel fuel	12.5	18.4	0.82

*Price to customer for agricultural use in Iowa.
†Data obtained during Nebraska Test 378 in 1941 applied to 1949 fuel prices.

when distress conditions no longer prevail, the price of LP gas, apart from seasonal variations, will probably continue to reflect the price level of competitive petroleum products and of crude oil itself. LP gas is, however, subject to seasonal variations in price, reflecting the difficulties in storing it when production is in excess of demand.

The erratic price structure of LP gas obscures definite and even general conclusions; but in our method of analysis, a variable "prevailing price" of all fuels is considered. Consideration of doubtful matters is avoided. Tractor operating costs may be broken down as follows: (1) Amortization, (2) taxes, (3) maintenance, (4) operator's labor, (5) lubrication, and (6) fuel. These items are all variables, depending upon locality, type of work, annual hours of work, and other circumstances of the individual operator. Therefore, for the purposes of this paper, the principles are best illustrated by applying them to a typical set of conditions representative at least of some tractor users, as follows:

1 *Basic of Analysis.* Analysis is predicated upon a hypothetical tractor delivering 30 hp at the drawbar, as determined by the Nebraska Tractor Test H (10 hr duration at 75 per cent of corrected maximum drawbar horsepower). This is generally representative of many tractor operations averaged throughout the years. Fuel-consumption rates are taken from officially published test reports.

2 *Original Tractor Cost.* The original cost of the tractor to the user is taken as the basis of subsequent depreciation, obsolescence, tax, and insurance expenses. Values used in this analysis were established from recent delivered prices together with official Nebraska Tractor Test performance. These tractor costs are as follows: Gasoline, $69.80 per dhp; LP gas, $75.00 per dhp; diesel, $92.70 per dhp. The cost of a suitable LP gas farm-storage system is not included, since where the price of this fuel makes it economical for tractor use, the storage facilities are available for domestic heating purposes. Depending upon circumstances, some part or all of the cost of such storage facilities may properly be included in the first cost and amortized accordingly.

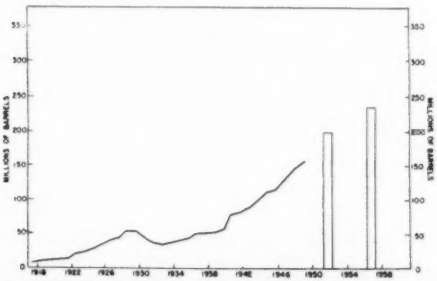


Fig. 3 Natural gasoline production in the United States from 1918 to 1949, according to the U.S. Bureau of Mines, with estimated production for 1952 and 1957

3 *Annual Hours of Work.* 1000 hr (Alternate assumptions of 500 and 1500 hr are also shown).

4 *Amortization Rate.* 10 per cent annually. Depreciation may be calculated by various methods depending upon the purpose of the evaluation. Straight-line depreciation, in which the total cost of the tractor is amortized in equal increments over its expected service life, is recognized as an acceptable method for operating-cost analysis and is used in this study.

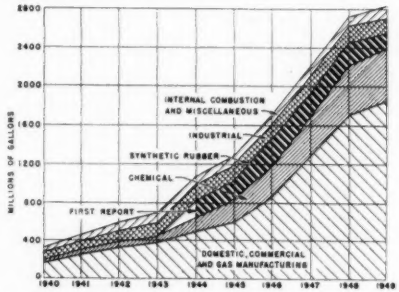


Fig. 4 Sales by years of LP gas according to principal uses

A nation-wide survey by F. C. Fenton and E. L. Barger of Kansas State College of 1325 tractors showed a mean life expectation of 11.2 years, which results in a somewhat lower amortization rate than that used for this analysis. However, the figure of 10 per cent was selected because it is the maximum rate allowed by federal and state income tax regulations locally applied.

5 *Maintenance.* Without exception, tractors today are of outstanding mechanical excellence and are little subject to fre-

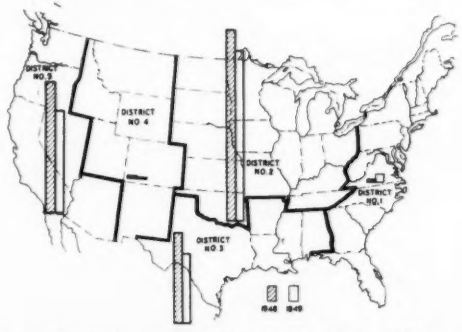


Fig. 5 Comparative use, by districts, in 1948 and 1949 of LP gas in internal-combustion engines, according to data from Mineral Industry Surveys, U.S. Bureau of Mines (MMS 1882), July 6, 1950

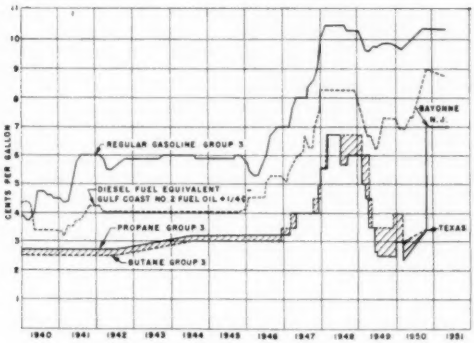

CENTS PER GALLON
REGULAR GASOLINE GROUP 3
DIESEL FUEL EQUIVALENT GULF COAST NO 2 FUEL OIL
PROPANE GROUP 3
BUTANE GROUP 3
BAYONNE N.J.
TEXAS
1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951

Fig. 6 Trends in tractor fuel prices

quent breakdown due either to defective materials or poor workmanship. Maintenance results largely from natural wear and is taken as 3 per cent of the delivered cost of the tractor per 1000 hr of use. Extensive investigation verifies that this reflects the experience of many farmers.

6 *Tax and Insurance Rates:* Prevailing local tax and insurance rates are as follows:

(a) Taxes: Valuation, 60 per cent; rate on valuation, $30 per thousand.

(b) Insurance: Fire and comprehensive at $5.50 per thousand; liability at $10 annually.

7 *Lubrication Cost.* This cost is on the basis of lubricating oil at 80¢ per gal, a 13-qt oil change every 125 hr of service, with one quart added to the engine for each ten hours of use. No grease or transmission lubricant costs are considered as these are very minor.

8 *Labor Costs.* These costs are not included, since in any specific instance it would be independent of the type of fuel used.

9 *Fuel Costs.* This cost is dependent upon three factors:

(a) Storage and handling losses (No attempt is made to evaluate these losses, but it is common experience that they are greater as fuel volatility increases. It might be assumed that since LP gas is stored under pressure, storage losses would be zero. However, experience shows that handling losses are large, due to "blowdown" at time of filling the tractor tank.)

(b) Rate of fuel consumption

(c) Cost per gallon.

Since tractor fuel is traded in gallons rather than by

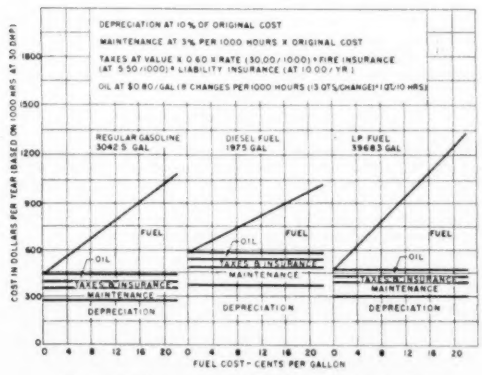

DEPRECIATION AT 10% OF ORIGINAL COST
MAINTENANCE AT 3% PER 1000 HOURS X ORIGINAL COST
TAXES AT VALUE X 0.60 X RATE (30.00/1000) + FIRE INSURANCE (AT 5.50/1000) + LIABILITY INSURANCE (AT 10.00/YR.)
OIL AT $0.80/GAL (8 CHANGES PER 1000 HOURS (13 QTS/CHANGE) = 1QT/10 HRS.)
REGULAR GASOLINE 3042.5 GAL
DIESEL FUEL 1975 GAL
LP FUEL 1968.3 GAL
FUEL
OIL
TAXES & INSURANCE
MAINTENANCE
DEPRECIATION
COST IN DOLLARS PER YEAR (BASED ON 1000 HRS AT 30 DHP)
FUEL COST - CENTS PER GALLON

Fig. 8 Total operating cost based on 1,000 hr per year

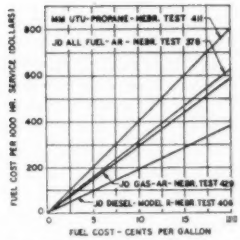

NEB UTU - PROPANE - NEBR. TEST 411
JD ALL FUEL - AR - NEBR. TEST 376
JD GAS - AR - NEBR. TEST 429
JD DIESEL - MODEL R - NEBR. TEST 406
FUEL COST PER 1000 HR. SERVICE (DOLLARS)
FUEL COST - CENTS PER GALLON

Fig. 7 Fuel cost based on rate of fuel consumption from Nebraska Tractor Test H, assuming 30-hp drawbar load

weight, all fuel-consumption data are so considered, using official Nebraska Tractor Test values. Fig. 1 illustrates specific fuel-consumption rates for the typical engines under consideration. Here it is again shown that engines operate most economically when developing from 75 to 100 per cent of the full power (operating maximum output), and for this reason, fuel costs are based upon published fuel-consumption rates during the 10-hr drawbar test (Test H), which is conducted within this range.

ANNUAL COST OF OWNING AND OPERATING TRACTOR

The total annual cost of owning and operating a farm tractor (in dollars) is the sum of depreciation, maintenance, taxes, insurance, lubrication, and fuel cost, and is based on the following calculations:

Depreciation = 0.1 × initial cost of tractor (Based on amortizing cost of tractor in ten years)

Maintenance = 0.00003 × initial cost × annual hours of operation

Taxes = Tractor value × percentage valuation × millage rate (Plotted values based on average tractor value over ten-year period as being one-half the initial cost, tax appraisal ratio of 0.60, and 30 mills tax rate)

Insurance = Fire and other extended coverage + liability

Fire, etc. = Value of tractor × insurance rate (Plotted values based on the average value of the tractor over a ten-year period or one-half the initial cost and insurance rate of $5.50 per 1,000 dollars valuation)

Liability = Liability rate (Charts based on $10 per year)

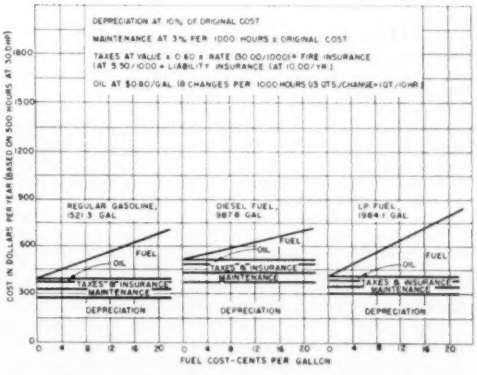

DEPRECIATION AT 10% OF ORIGINAL COST
MAINTENANCE AT 3% PER 1000 HOURS X ORIGINAL COST
TAXES AT VALUE X 0.60 X RATE (30.00/1000) + FIRE INSURANCE (AT 5.50/1000 + LIABILITY INSURANCE (AT 10.00/YR.)
OIL AT $0.80/GAL (8 CHANGES PER 1000 HOURS 13 QTS./CHANGE = 1QT./10 HR.)
REGULAR GASOLINE 1521.3 GAL
DIESEL FUEL 987.8 GAL
LP FUEL 1984.1 GAL
FUEL
OIL
TAXES & INSURANCE
MAINTENANCE
DEPRECIATION
COST IN DOLLARS PER YEAR (BASED ON 500 HOURS AT 30 DHP)
FUEL COST - CENTS PER GALLON

Fig. 9 Total operating cost based on 500 hr per year

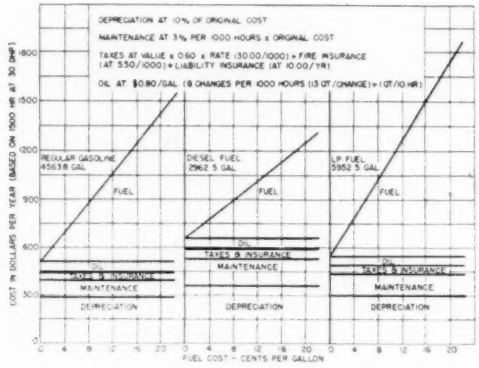

DEPRECIATION AT 10% OF ORIGINAL COST
MAINTENANCE AT 3% PER 1000 HOURS x ORIGINAL COST
TAXES AT VALUE x 0.60 x RATE (30.00/1000) + FIRE INSURANCE (AT 5.50/1000) + LIABILITY INSURANCE (AT 10.00/YR)
OIL AT $0.80/GAL (8 CHANGES PER 1000 HOURS (3 QT./CHANGE) + 1 QT./10 HR)
REGULAR GASOLINE 4563.8 GAL
DIESEL FUEL 2962.5 GAL
LP FUEL 3952.5 GAL
FUEL
OIL
TAXES & INSURANCE
MAINTENANCE
DEPRECIATION
COST IN DOLLARS PER YEAR (BASED ON 1500 HR AT 30 DHP)
FUEL COST – CENTS PER GALLON

Fig. 10 Total operating cost based on 1,500 hr per year

$$\text{Oil Cost} = \text{Total gallons of oil used per year} \times \text{cost per gallon}$$

$$\text{Fuel Cost} = \text{Total gallons of fuel used per year} \times \text{cost per gallon}$$

Notations:

I = Initial cost of tractor
H = Hours of operation per year
K_1 = Ratio of taxed value to actual value
M = Millage rate
K_2 = Insurance rate for fire and other coverage
K_3 = Liability insurance cost
K_4 = Over-all oil consumption rate in gallons per hour
K_5 = Fuel consumption rate per hour
C_o = Cost of oil per gallon
C_f = Cost of fuel per gallon

The total annual cost may be set up as a mathematical formula, viz:

$$\text{Cost per year} = I\ (0.1 + 0.00003H + K_1M/2 + K_2/2) + K_3 + H\ (K_4C_o + K_5C_f)$$

Using all previously assumed values, plot cost graphs.

$$\text{Cost per year} = I\ (0.11175 + 0.00003H) + 10 + H\ (0.051\ C_o + K_5C_f)$$

On the basis of Nebraska Drawbar Test H, the fuel cost in dollars per 1,000 hr of service at 30 dhp (equivalent to 30,000 dhp-hr) has been determined for representative LP gas, gasoline, distillate, and diesel operations. These values are shown graphically on Fig. 7 as ordinates against fuel cost per gallon as abscissas. No John Deere tractor burning butane has been tested at Nebraska, so with no official data of our own available, it became necessary to evaluate propane fuel consumption on the performance of the Minneapolis-Moline Model UTU tractor, so far the only tractor tested at Nebraska using this fuel.

For any given tractor operation, the annual fixed costs are depreciation (amortization), taxes, and insurance. Maintenance, lubrication, and the amount of fuel used are taken as variable functions of operating hours; using tractor costs, amortization, taxes, insurance, and lubrication costs at values previously established. In Fig. 8, total annual costs on the basis of 1000 working hours are plotted against fuel costs per gallon for each of the three fuels under consideration.

Similar costs on the assumptions of 500 and 1500 hr of operation annually are comparably plotted in Figs. 9 and 10, respectively. These comparisons accent the variation in proportion of fixed costs to total cost as the base of annual hours of operation is changed. It is evident that the use of low-cost fuel becomes an increasingly important factor when the annual hours of use is high. Under these conditions, the higher initial cost of LP gas and diesel tractors is speedily recovered and subsequent operations are increasingly profitable.

Herein is developed a method which can be reliably used as a tool by the manufacturer to evaluate and establish the economics resulting from operating with any type of fuel when the cost to the user and value of service are known. Likewise, tractor users can intelligently justify whatever additional expense may be involved in the purchase of tractors to operate on lower cost fuels. And, in turn, the farm equipment dealer may consider each case on its merits and best serve his customers by applying a factual basis when recommending operation on any specific type of fuel.

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AUTHOR'S NOTE: The author gratefully acknowledges the cooperation of the Standard Oil Co. (Ind.), Phillips Petroleum Co., Gulf Refining Co., and of the personnel of the research and product engineering divisions of the John Deere Waterloo Tractor Works which made the preparation of this paper possible.

Opportunities in Sprinkler Irrigation

(Continued from page 471)

Sprinkler irrigation is in a strong position to compete for its share of able young men. Running water has always appealed to many of the best scientific and engineering minds in the world. This has resulted in the technology of water reaching a high state of development. It has resulted at times in active competition for comparatively limited opportunities to earn a living in this field. Sprinkler irrigation substantially and directly increases those opportunities.

The supply of agricultural engineers especially qualified for work in sprinkler irrigation may not catch up with the demand in the forseeable future. It can increase considerably within a few years, however, if the opportunity for training and challenging careers in this branch of agricultural engineering are provided and made known to able young men. It also seems probable that some of the load of subengineering service and applications work might be carried by agricultural curriculum graduates specially trained in farm mechanics.

The Engineer Must Serve

THE engineer's innate ability to determine the shortest distance between two points makes him invaluable in rendering service under various categories listed as opportunities for our ever-growing, complicated democracy. Indeed, straight thinking at all levels of government, and the expenditures of the substance of the population in the form of tax money, is a major question in the maintenance and the development of our country. In these fields, the engineer must serve directly either as in a career, or indirectly as a volunteer in limited areas. We must help to maintain a simplicity and economy that will enable our government, with its multitude of services to the people, to balance the costs against the necessities of human existence. — Frank H. Neely in *Mechanical Engineering* for June, 1951.

Making a Creek Flow Gently

By Howard Matson
MEMBER ASAE

A CREEK is by nature rowdy and boisterous and does not respond readily to restraining influences. A creek is a nervous thing; it jumps up and down rapidly and frequently and is always in a hurry to get to some other place. And there are lots of creeks. That is just about the story of why annual flood damages in creek watersheds are much greater than the flood damages along major rivers. Creeks flood more land than do rivers, and they flood more frequently.

In discussing the flood problems of creeks and rivers, I shall use the Washita River watershed as an example because we have more complete and accurate information about it than for any other watershed with which we are concerned. The Washita River originates in the northeast corner of the Texas Panhandle and flows generally southeastward for 300 miles, emptying into Lake Texoma. The area of the watershed is approximately 8100 square miles. There are 104,000 acres of flood plain along the main stem of the river, and flood damage on this area averages $1,390,000 annually. In contrast, in the tributary watersheds there are 265,000 acres subject to flooding, on which the average annual flood damage amounts to approximately $4,375,000.

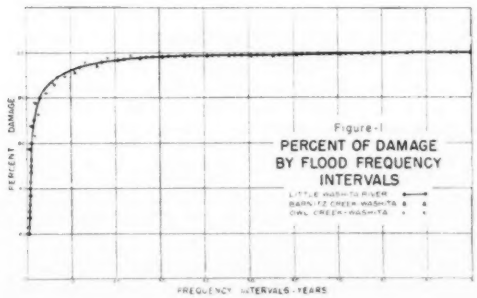
Annual direct flood damage to crops and pastures amounts to $2,912,000 in the tributary watersheds as compared to $445,500 along the main stem. It is significant that crop and pasture damage constitutes two-thirds of the annual flood damage in the tributaries, but only one-third of the annual flood damage along the main stem.

Along the central portion of the Washita River there has been an average of two damage-producing floods annually. The average for several of the major tributary watersheds has been five damage-producing floods annually. The high frequency of occurrence of tributary floods is due to the fact that most such floods are caused by short-duration high-intensity storms which cover a relatively small area. Such storms occur much more frequently than the long-duration storms over large areas which produce most of the main stem floods.

Fig. 1 is a composite curve for three typical tributaries of the Washita River, showing the relationship between flood damage and flood magnitude. It indicates that 85 to 90 per cent of the average annual tributary flood damage is caused by floods not exceeding a magnitude to be expected once in 5 to 10 years. Protection against floods of this magnitude can be provided, where it is physically feasible, at a fraction of the cost of complete flood protection. And land which is not flooded more frequently than once in 5 to 10 years can be profitably used for crop production.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Soil and Water Division.

The author: HOWARD MATSON, chief, regional water conservation division, Western Gulf Region, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Tex.



In planning upstream protective works in a creek watershed we obtain information on watershed characteristics, condition and use, rainfall-runoff relationships, flood frequency and magnitude, and sediment sources and production rates. We make profiles and cross sections of the stream channels and valleys, map the flood plain areas, and collect information on floodwater and sediment damages.

Possible sites for floodwater-retarding structures are located by stereoscopic examination of aerial photographs. From these, the feasible sites are determined by field examination and surveys and approximate designs are made to furnish information on capacities and costs. The planned system is then selected by flood routing and a determination made of any need for channel improvement or floodway construction. Sites are selected and approximate designs prepared for structures needed for floodwater diversion and gully and sediment control.

The work plan includes (1) a description of the watershed and of flood problems and damages; (2) a description of the hydrologic, hydraulic, sedimentation and economic investigations made and their findings; (3) information on the types and amounts of land-treatment measures and practices needed; (4) pertinent data on the structures and works planned for floodwater retardation and for erosion and sediment control; (5) an analysis of the expected physical and economic effects, and (6) a comparison of the benefits and costs.

As an example, let us take a look at the Sandstone Creek watershed in Beckham and Roger Mills Counties in the Rolling Red Plains of western Oklahoma. The watershed is 15 miles long, averages 6 miles in width, and has an area of 65,000 acres. The upland topography is generally steep and the soils are shallow. Less than 15 per cent of the upland is cultivated, the remainder being usable only for range purposes. The cultivated upland is highly erodible and much of the topsoil has been lost by water and wind erosion.

There are 4700 acres of flood plain, two-thirds of which is cultivated. The remainder has been flooded too frequently for any cropland use. The flood plain soils are generally deep, medium-textured and permeable. Their fertility is high, but has been reduced considerably during the past 40 years by deposition of less fertile sediments.

Beef-cattle production and dairying are the major enterprises; cotton and wheat are the principal cash crops. Ninety per cent of the cultivated bottomland and 70 per cent of the cultivated upland are used for feed crops.

Floods have occurred on an average of more than 9 times per year, approximately one-third of which have been damage-producing. Any storm on the watershed producing as much as ¼ in of runoff in a period of from 8 to 10 hr has caused flooding. Average annual flood damages are estimated to be $58,700, of which crop and pasture damages amount to $40,100.

Sedimentation damages on the flood plain have been high, affecting 4115 acres to some degree. There has been 10 per cent damage to 735 acres, 20 per cent damage to 265 acres, 50 per cent damage to 570 acres, and 75 per cent damage to 170 acres. The annual rate of sediment output per square mile varies from 1 to 3½ acre-feet in various parts of the watershed.

Twenty-four floodwater-retarding structures are being built in this watershed. They range in total capacity from 134 to 4576 acre-feet. Their designed floodwater-detention capacities range from 2.91 to 6.66 in of runoff from their watersheds. The construction cost of these 24 structures will be approximately $850,000.

Seventeen drop-inlet-type structures are being built for grade stabilization and sediment *(Continued on page 480)*

Tank Truck Collection of Milk from Farms

By R. L. Perry
MEMBER ASAE

TEN-GALLON cans are unreasonably small containers for collecting milk from patrons who produce as much as 1,000 gal per day. This was recognized in 1940 by the Carnation Milk Company of Los Angeles*, who pioneered in tank-truck collection from farms. Since stainless-steel insulated-tank trucks were already in use for interplant transport, it seemed logical to use them also for collection from large producers. A plant-type storage vat was installed in each producer's milkhouse, where both morning and evening milkings were cooled and held until the tanker arrived for pickup. The Lucerne Company of Oakland adopted the system in 1942, several other firms soon after, and now a large proportion of the market milk in both the Los Angeles and San Francisco milksheds is collected by the farm tank-tanker system. Tanks designed for the purpose are now being made by several manufacturers.

The principal advantages of the farm tank-tanker system are:

For the patron:

1 Simpler milkhouse routine
2 Lower transport costs (for large patrons)
3 Elimination of milkhouse spilling and can stickage loss
4 Opportunity to check daily milk volume and fat test

For the processor:

1 Better quality milk, resulting from elimination of both bacterial and metallic contamination from imperfect cans
2 Reduction of tendency of rancidity development at certain seasons
3 Lower plant-handling costs
4 Elimination of can maintenance and replacement

For the driver:

1 Much less labor

For the public:

1 Better milk quality, and in the long run lower prices.

This is a revision of a paper presented at the annual meeting of the American Society of Agricultural Engineers at East Lansing, Mich., June, 1949.

The author: R. L. PERRY, professor of agricultural engineering, University of California, Davis.

*Roadhouse, C. L.: Tank Truck Market Milk Collection from Farms. *Milk Dealer*, v. 35, pp. 44-45 (December, 1945).

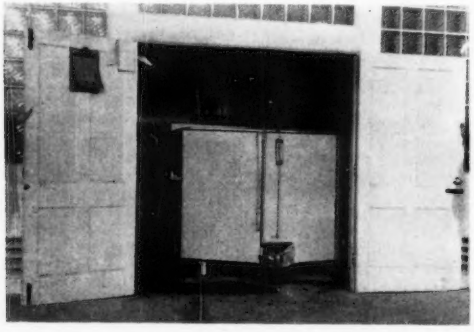


Fig. 1 Insulated farm tank, in milkhouse, with aerator elevated to deliver milk to tank by gravity. Double door is wide enough for tank to pass through at time of installation

The system proved so desirable with large producers that milk processors are anxious to extend it to small producers. At present, many feel that the tanker route must average 300 gal per stop in order not to exceed cost of collection in cans. Quality improvement, however, may actually offset increased costs for farms producing less than 300 gal per day.

The system requires all-weather roads to the milkhouse, with easy-driving lanes and sturdy bridges. For handling rejected milk, the system is less flexible than the can system. The milk inspector, who thus has to do his work in the field, must arrive at the ranch before the tanker.

Although a large volume of milk is being handled by the system, the number of farm tanks is not very large. Orders have been divided among manufacturers, so that several designs have evolved. Since manufacture is on a job-shop basis, the cost of small tanks is relatively high. Pending development of minimum sanitary standards by the California State Bureau of Dairy Service, a committee of members from Los Angeles city and county health departments and from industry personnel drew up "Recommended Provisions for Regulation of Farm Tanks." These were adopted December 14, 1947, as a guide in interpreting the sanitary provisions of the State Agricultural Code. If the system develops generally, it would seem desirable for the Subcommittee on Sanitary Standards of the Dairy Industry Committee, the U.S. Public Health Service, and the International Association of Milk Sanitarians to establish minimum sanitary standards in order to avoid the high costs of construction that result from conflicting codes.

Two general types of farm tanks are in use. Where adequate, the existing refrigeration system and aerator are retained, and the aerator is elevated to allow milk to flow by gravity into the tank (Fig. 1). In such cases, the tank is not equipped with refrigeration and so it must be insulated well enough to keep the milk from rising more than 3 F in 18 hr at a room-to-milk difference of 60 F (e.g., at room temperature of 100 F and a milk temperature at 40 F). This requires at least two inches of cork or its equivalent, and a minimum of metal connections between vat lining and exterior. A few tanks have been equipped with "sustaining" direct-expansion coils, but this does not seem necessary if the milk has been well cooled and the tank is well insulated.

In the elevated position the aerator is more difficult to clean and sterilize, and a higher milkroom ceiling may be required. It then becomes impractical for the milker to carry the milk to a strainer vat that would deliver to the cooler by gravity. The strainer vat therefore is lowered to alley level, and a 1-in sanitary pump is provided to raise the milk to the cooler trough.

Refrigerated tanks of cold-wall construction are also used. Direct-expansion refrigeration channels are attached to the vertical walls, and in some models, also, to the bottom of the vat, and are covered with insulation. In some of these vats, the milk inlet pipe merely directs the milk stream against the wall, primarily to prevent splashing and foaming. Refrigerated surface is effective for cooling milk only as it becomes submerged.

In at least two designs of cold-wall tanks, a trough similar to that above a surface cooler distributes milk over the entire wall surface. One of these, a rectangular model, has a water-cooled wall section above the milk level, to retain the economy of water precooling and reduce the load on the refrigeration unit. In spite of its economy, some sanitarians do not recommend this feature because the water-cooled surface cannot be washed after the first milking, and it may remain warm enough to permit bacterial growth. If the water were drained from the coil between milkings, thereby reducing the heat capacity of the section and preventing leakage which would tend to maintain water temperature, the adjacent refrigerated

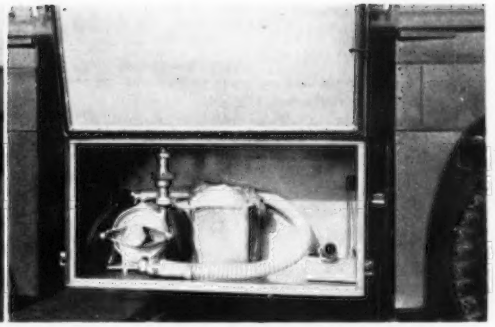


Fig. 2 *(Left)* Semitrailer tanker with compartment for pump, hose, and sample bottles. Fig. 3 *(Right)* Dusttight pump compartment, with ice box. Note removable sanitary check valve in pump discharge, which prevents backflow after milk is pumped directly into tanker.

section might provide sufficient cooling to retard growth. No adequate data on this point are as yet available.

A few field observations indicate that the milk is being well cooled by both types of cold-wall tanks, being closer to 40 than 45 F. With the simple cold-wall tanks, refrigerant temperatures and pressures are lower during the first part of cooling, resulting in slightly poorer performance of the refrigeration system.

In one region, each farm tank was equipped with a pump. There is an obvious economy, however, in carrying the pump on the tanker, so that one pump can serve all the farm tanks on a route. This stimulated development of a sanitary dusttight, insulated compartment on the tanker, where pump, hose and sample bottles are protected by ice-refrigeration (Figs. 2 and 3).

Refrigeration requirements of cold-wall tanks have been estimated by designers and confirmed by field experience. With a milking time of 3 hr per milking, the refrigeration system should be able to cool at a rate of one-sixth of the tank capacity per hour, from 95 to 35 F, a load of 8,000 Btu per hr per 100 gal of capacity. This requires 1 hp for the refrigeration compressor motor per 100 gal of capacity, for air-cooled compressors operating at 28 F evaporator temperature and 100 F condenser air temperature, or about ⅔ hp for water-cooled units with 80 F condenser water temperature.

Installation of large tanks in existing milkhouses usually requires removal of a section of wall. New milkhouses are being built with double doorways wide enough to pass any size of tank which might reasonably be required, as shown in Fig. 1.

The tank must be stable in its dimensions if volumetric measurement is to be used. It must be fixed permanently in the position in which it is calibrated, to avert accidental or fraudulent modification of calibration. The calibration must be made and certified by an agency which has the confidence of the producer, purchaser, and responsible weights-and-measures authority.

The truck driver is a key man in this system. He must be a licensed weigher and sampler and must be alert to reject any milk too high in temperature or apparently off in odor. If the program is to be extended to smaller dairies, his routine at the ranch must be arranged to require the minimum of time. This routine is:

1 Spot the truck within close limits to permit connection to the tank.
2 Enter the milkhouse, raise the tank cover, inspect the milk.
3 Insert gage stick at the proper point and note milk level.
4 Read gallons from calibration chart, return gage stick, and record volume on patron's daily tag.
5 Start agitator motor.
6 Note milk temperature, and complete tag record.
7 Remove cap from patron's previously assembled milk pipe line.
8 Step out to truck, open pump compartment cover, and connect hose.
9 Open manual valve at pump.
10 Take sample bottle and sample dipper from pump compartment.
11 Re-enter milkhouse, and, after proper agitation time has elapsed, sample contents of vat.
12 Open tank valve.
13 Start pump.
14 Step out, place sample bottle in cubicle.
15 When tank is dry, shut manual valve at pump.
16 Stop pump.
17 Disconnect hose, replace in compartment, shut cover.
18 Return to cab and drive off.

Costs of milk collection by the can and by the milk tank-tanker system have been carefully analyzed by Clarke, from records of 119 trucks covering 6½ million miles of truck operation. Observations were also made on driver and plant employee time requirements for each system. A summary for two equipments of equal capacity is given in Table 1.

From these data, or similar data adjusted for local area costs and conditions, the time per trip and the cost per gallon can be estimated for any combination of number of patrons, daily gallonage, and milage. An example for a route of 100 mi, for a load of 3500 gal, is shown in Fig. 4.

It will be noted that the costs are nearly the same for pickups of 250 to 700 gal per farm. The saving from elimination of cans and reduction of plant labor is very nearly equal

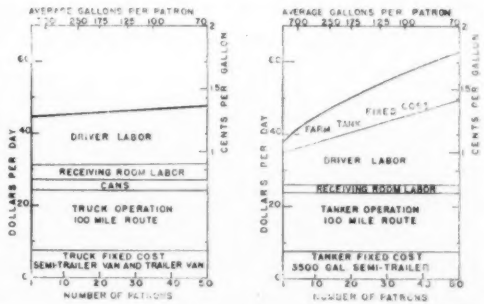


Fig. 4 Effect of number of patrons on cost of milk collection by cans and by farm tank-tanker system. Costs based on collecting 3,500 gal on a 100-mile route. Farm-tank fixed cost based on 70 per cent average fill.

TABLE 1. UNIT COSTS OF MILK COLLECTION IN CANS AND BY FARM-TANK TANKER SYSTEM*

	Can collection	*Tanker collection*
Truck fixed costs:		
Tractor, semitrailer van, and trailer van for 350 cans	$2,733 per yr	
Tractor and semitrailer tanker, 3500 gal		$2,755 per yr
Truck operating cost	16.78c per mile	16.22c per mile
Driving time	2.727 min per mile	2.727 min per mile
Driver's time at ranch:		
Fixed, per ranch	2.12 min	10.1 min
Variable:		
Handling cans	0.0457 min per gal	
Pumping milk		0.0167 min per gal
Plant time:		
Unloading cans	0.0237 min per gal	
Pumping		0.0167 min per gal
Receiving room:		
Per patron	0.261 min	
Per gallon daily	0.0206 min per gal	
Washing tanker		25.3 min per trip
Can fixed and maintenance costs, 10-yr life, 2 retinnings, 2 cans per 10-gal peak capacity	0.0797c per gal	
Farm tank fixed cost per year, based on 300-gal insulated tank with pump, $1494 installed		$190 per yr†

*Clark, D. A., Jr.: A Comparative Analysis of the Cost of Operating Milk Collection Routes by Can and by Tank in California. Mimeo Report No. 91. Giannini Foundation of Agricultural Economics. University of California, Berkeley, Calif. October, 1947.

†Will be higher per gallon for tanks smaller than 300 gal and for cold wall tanks.

to the added fixed cost of the farm tank. This suggests that careful consideration be given to allocation of costs between producer and processor. For small cold-wall tanks, costs are considerably higher than those for the insulated tanks observed by Clarke, and so the cost to the small producer may be higher than indicated above. The rental price of 2c per lb butterfat, which has been used in some producer-processor contracts, is also higher than Clarke's figure for insulated tanks.

The desirability of reducing driver time per ranch is emphasized in Fig. 4. If the driver fixed-time were reduced from 10.1 to 5 min per ranch, the total costs of tank collection would be no greater for patrons producing as little as 7 cans per day than for 100-can patrons.

In order to improve quality, processors are interested in extending the system to manufacturing milk dairies. It has even been suggested that with adequate refrigeration, collection every other day would be feasible for small dairies. This would reduce the collection cost but would increase farm-tank fixed costs per gallon by about 50 per cent.

Cleaning and sterilizing farm tanks is a new problem for the producer. Steam sterilization does not seem practical for insulated refrigerated tanks because of the thermal stresses which ensue and the difficulty of rapidly heating and cooling the surfaces. The recommended procedure† for washing is: (1) Rinse as soon as possible after use, with warm water, (2) disassemble all removable parts, (3) brush all surfaces with washing solution of proper strength, (4) rinse with warm water, (5) reassemble, and (6) sterilize.

Sterilization is being carried out by brushing or spraying with chlorine solution at a concentration of 250 ppm of available chlorine. A paste of proper chlorine compound is also used, with the advantage that complete coverage is easier to check. Quaternary ammonium compounds are also being used.

SUMMARY

1 Tank truck collection offers definite improvement in milk quality.

2 All-weather roads are a necessity for the system.

3 The truck driver has a greater responsibility.

4 The producer needs training in appropriate cleaning procedures for the tank.

5 Tank truck collection is more economical than can collection for dairies averaging over 300 gal per day.

6 Extension to smaller producers is more costly at present, because of high driver time per stop, and because of high costs per gallon of custom-built, cold-wall tanks of small capacities. Reduction of driver time per stop and quantity production of cold-wall tanks might make the two systems of about equal cost, or even give lower costs with the tank system.

†Ellison, H. F.: Farm Tank Installation and Operation Mimeo-Dairy Industry Conference — Davis, Calif. (Feb. 1, 1949).

Making a Creek Flow Gently

(Continued from page 477)

control. The cost of building these structures will total approximately $85,000.

Only 4.3 per cent of the flood plain is within the pools of the floodwater retarding structures. These structures will control the runoff from 75 per cent of the watershed. A runoff of 3.75 in is not expected to occur more frequently than once in 25 years, and most of the detention pools have a capacity below spillway level in excess of this amount.

A drop-inlet-type pipe or culvert is used to release the floodwater at a rate within the capacity of the stream channels below the structures. In the Sandstone Creek watershed these structures are designed for a maximum release rate of 8 to 10 second-feet per square mile of drainage area. However, the channel of the Washita River throughout most of its length has a capacity of only two second-feet per square mile. Since our present information indicates that the runoff from approximately 40 per cent of the Washita River watershed may be controlled by floodwater-retarding structures, our current designs provide for a maximum release rate of 4 to 5 second-feet per square mile.

Approximately 95 per cent of the total flood-plain area is protected by the system of floodwater-retarding structures, and it is estimated that future flooding will not exceed 110 acres annually, causing an estimated average annual damage of only $1236. The estimated reduction in annual flood damages is $57,461.

In addition to the reduction in flood damages, material benefits will result from more intensive use of flood plain lands. Small grain is now the principal bottomland crop because flooding has been too frequent to permit the growing of alfalfa. In the future it is expected that approximately one-third of the flood plain will be used for alfalfa and it is estimated that the annual net benefit from more intensive land use will amount to $11,019.

It is estimated that the system of floodwater-retarding structures and the channel-improvement work will produce approximately $2.00 of benefit for each dollar of annual cost.

This description would not be complete if it failed to indicate the interest of the farmers and ranchers in all phases of this work.

Soil and water conservation plans have been prepared on 58,900 acres, or 90 per cent of the watershed, through cooperative agreement between the farmers and ranchers and the Upper Washita Soil Conservation District. There are 7 active conservation groups, which include 87 per cent of the farmers and ranchers in the watershed. Approximately two-thirds of the needed soil and water conservation practices have been applied. Easements on the sites of the 24 floodwater-retarding structures and the 17 drop-inlet *(Continued on page 482)*

Some Agricultural Engineering Problems in Soil and Water Conservation

By Louis P. Merrill

ENGINEERS whose genius has been manifested in such noteworthy feats of design and construction as Hoover Dam, San Francisco Bay Bridge, and the Empire State Building, have been widely acclaimed. They have made great contributions to the science of engineering and they deserve all the credit they have received.

There is another group of engineers, however, whose accomplishments are even more important to the general welfare of the American people. These are the agricultural engineers who are devoting their talent and energy to the conservation and efficient use of soil and water, the most precious resources of this or any other country. Their achievements in this field have contributed much to the high standard of living which we enjoy. Upon their continuing efforts depends in large measure our hope of maintaining our high standard of living in spite of our increasing population and our dwindling soil resources.

Agricultural engineers are not commonly associated with the design and construction of large engineering works. The importance of the agricultural engineer to the well-being of the American public lies in the cumulative effect of the many small jobs which he undertakes and carries through.

The agricultural engineer working in the field of soil and water conservation is concerned primarily with the engineering problems of the farm and ranch. His job is to apply the basic sciences, tempered with a lot of sound judgment, toward our objective of the use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement. There are approximately six million farms and ranches in the United States, and engineering problems exist on every one of them. These problems range from the design and construction of vegetated waterways and systems of terraces for the control and safe disposal of runoff to the development of drainage or irrigation systems serving hundreds of acres of highly productive land.

This level party is locating contours to stake out level-border irrigation system. The field has just been cleared and leveled for cultivation

The agricultural engineer doing such work must have a knowledge of several branches of engineering and must be familiar with the characteristics and capabilities of soils and vegetation. Above all, he must have the ability to work with farmers and ranchers. To do this successfully, an engineer must be able to convert technical language into terms which a layman can understand.

I believe that the most important job of the agricultural engineer today is the conservation and control of water on the cultivated lands and grasslands of the world. Uncontrolled flowing water is the greatest destructive agent which the farmer and rancher must combat. By controlling the flow of runoff, severe and lasting damage to land can be prevented.

In most irrigated areas a high percentage of the available water supply has been lost or wasted annually through ditch seepage, excessive evaporation, and overapplication of water, and much land has been damaged by waterlogging and salt accumulation. By improving irrigation systems, land leveling, better methods of water application and the use of needed crop rotations, we can conserve our water and soil resources and at the same time produce higher crop yields with less labor.

This is an address delivered at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951.

The author: LOUIS P. MERRILL, regional director, Western Gulf Region, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Tex.

(Left) The metal windlass-type, elevating check gate shown here, to control flow of water in the irrigation ditch, was designed by agricultural engineers of the U.S. Soil Conservation Service • *(Right)* This picture shows corrugated, 36-ft lands seeded to white Dutch clover and Dallis grass. Field drain is in foreground

In other areas we are troubled with an overabundance of water. Many millions of acres of our best agricultural land are not being used to their full productive capacity because of inadequate drainage. By improving the drainage facilities through sound engineering, and by growing needed rotations of crops, agricultural production can be increased greatly.

The U.S. Soil Conservation Service has the largest number of agricultural engineers thoroughly grounded in the solution of water conservation and control problems of any group or agency in the world. We have 338 of these engineers in our Western Gulf Region, which includes the states of Texas, Oklahoma, Arkansas, and Louisiana. It may be of interest to consider briefly some of the problems these men encounter in their daily work.

The most common problem in most of the Western Gulf Region, as in other humid and subhumid areas, is the design of a water-disposal system for sloping cultivated land. Water-disposal systems are needed on more than 30 million acres of land in this region. The function of such a system is to collect the runoff water, resulting from rain which falls at a rate greater than can be absorbed by the soil, and conduct it from the field without erosion. This is accomplished by intercepting the flowing water at intervals, by a system of properly spaced terraces, before the volume and speed of the water become destructive. The problem of determining the spacing, size and grade of terraces to control erosion as economically as possible has been solved by agricultural engineers.

After the runoff water has been collected by the terraces, it must be carried safely down the slope. The design of a waterway for this purpose requires several types of specialized knowledge on the part of an agricultural engineer. He must be able to determine the peak rates of runoff the area will produce under rains of various intensities and amounts. This in turn requires a knowledge of the rate at which the soil will absorb water, and the effect of different types of cover on this rate. The engineer must understand the principles of flow of water in open channels so that he can determine the width and depth of waterway needed. He must know the ability of various kinds of vegetation to resist erosion under heavy flows of water, and must be familiar with their growth characteristics so that he can make allowance for the retarding effect of vegetation on the flow of water.

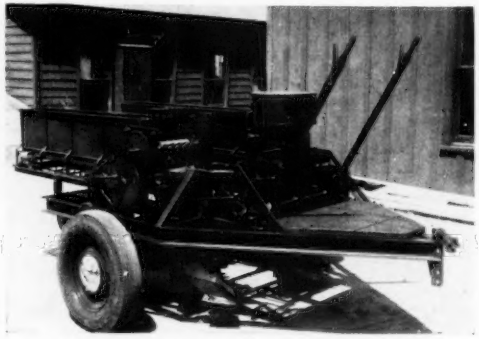
Where the volume of water to be carried from a terrace system, the steepness of the slope, or the nature of the soil precludes the use of a vegetated waterway, the agricultural engineer must be capable of designing suitable structures to lower the water to a stable grade. In addition to a knowledge of concrete and structural design, this involves familiarity with the hydraulic principles of the flow of water through or over various types of structures.

Since approximately six million acres are now being irrigated in this region, the planning of improved irrigation is one of the major jobs of our agricultural engineers. The engineer must design water-distribution systems which will deliver water to all parts of irrigated fields at a rate which will permit efficient use of water and man power. To do this he must be familiar with such factors as the permeability and the water-holding capacity of the soil, the water requirements of different crops, the water losses to be expected from seepage and evaporation in delivery canals, and the effect of various crops on the flow of water in borders. Occasionally he must design a structure to impound or divert water as a source of supply.

The agricultural engineer is frequently called upon to furnish information on the drilling and developing of wells for irrigation where adequate ground water supplies are known to exist. Also, he needs to know how to select pumping equipment to fit the yield and water-lift characteristics of a well.

In this region there are more than 25 million acres of land which need improved drainage or the provision of new drainage facilities. This is an enormous job and represents possibly the greatest single opportunity in the United States for a large-scale increase in agricultural production.

In drainage work the agricultural engineer, in addition to his knowledge of hydrology, hydraulics, and structures, must be familiar with the tolerance shown by all types of crops to standing water. With this information he knows how fast the water must be removed from a field in order to prevent damage to crops. The rate at which the water must be removed governs the size of ditch that must be installed. He must also be acquainted with the soils of the area so as to design ditches with side slopes that will stand up. He must design drainage systems so that they can be maintained by the farmer or rancher with available equipment and a minimum expenditure of time or money.



This Bermuda-grass sprig planter, designed and developed by SCS agricultural engineers, is capable of planting 2 acres an hour

There are many other jobs or problems which confront the agricultural engineer daily. Some of the more important of these are development of plans for livestock water supplies; diversion of hill water so it will not damage lower land; flood-control structures to prevent flood damage to agricultural lands; and development of plans for prevention of erosion along state, county, or farm roads. The agricultural engineer must be constantly alert to discover ways of improving farming equipment to make it more adaptable for use with conservation practices. Often he must develop special equipment to handle the job of applying conservation treatment to the land, such as sod-harvesting equipment, sod-planting equipment, native grass seed harvester, and native grass seed drills.

At all times the agricultural engineer must develop his plans so as to make the best possible use of the farmer's or rancher's existing resources in power, equipment, labor and materials. He must also make his work fit smoothly into the entire coordinated soil conservation program developed for each individual farm and ranch.

The work of the agricultural engineer is not so glamorous as that of engineers participating in the design and construction of the awe-inspiring installations. Nevertheless, his work calls for a blending of engineering knowledge and horse sense unsurpassed in any other field of engineering. He must be a sound engineer, a diplomat, a practical thinker, and an energetic doer. The future welfare of the world depends in considerable measure upon how well he does his work.

Making a Creek Flow Gently

(Continued from page 480)

structures have been granted to the soil conservation district free of charge, and legally recorded. Twenty-two of these structures have been completed or are under construction and the other two will be built next fiscal year. Groups of farmers benefited by these structures have signed agreements with the soil conservation district obligating themselves to maintain these structures in good condition.

We feel that the Sandstone Creek watershed is an excellent example of what can be accomplished in upstream flood protection with the whole-hearted support and cooperation of the farmers and ranchers living in the watershed.

Soil Survey as a Basis for Equalization of Rural Assessments

By Walter W. Weir
MEMBER ASAE

THE use of soil survey data by the county assessor in the determination and equalization of rural land assessments may be a common practice in several states, but the methods used by the University of California, and California assessors, in preparing the material for this particular purpose, should be of interest to agricultural engineers. The modern soil survey contains much more detail than those made only a few years ago. It is a multipurpose inventory of this basic natural resource. Soil surveys are now in sufficient detail and are on a scale that makes them suitable for all except possibly the most intricate of test-tube studies.

In California the Division of Assessment Standards, State Board of Equalization, is working on a plan which will standardize land assessments on a statewide basis rather than permitting each county to set up its own scheme. The tax rate will, of course, vary with the amount of money that is needed by the individual county. The ratio of the productive capacity of one soil to another is, however, not dependent upon county lines. This ratio can be established, and should be uniform, wherever the particular soils are found.

A knowledge of the soil factors which govern its productive capacity is essential before standardization is possible. The purpose of this paper is to explain the methods of getting the needed information from soil-survey reports and putting it in useful form.

There are less than a half dozen persons who can give offhand a reasonably good description of all of the more than 425 named soil series in California. To be sure, it is seldom that more than thirty or forty of these occur in any one county, but even this number is too many for the average nonsoils man to remember and he is likely to give up in despair.

Soil survey reports are semitechnical, and the information needed for some special purpose may be difficult to dig out from among all the data presented unless some help is available from the technical men.

We are trying to give this help by interpreting the soil data for the county assessor, and we believe that we have met with considerable success and are really filling the needs.

If I mention just a few of our common and well-known soil series such as Hanford, Yolo, Vina, Metz — I could add fifteen or twenty more similar soils — what would these names mean to you? Probably nothing more than a group of names that you have never heard before, but if I tell you that these are all very recent alluvial-fan deposits, having no important agricultural differences, all capable of successfully producing a wide variety of crops, you would no doubt get some idea of these soils. If you were an assessor that is really all you would need to know about these soils, and you would not care that they differ in the character of the parent material from which they are derived, in reaction and in color.

You may ask, if that is all the county assessor wants to know, why we go to the trouble of making all the separations? The answer to that question is simple: (1) It is not possible to combine soils into any kind of intelligent grouping until you know what you are combining, and (2) soil surveys are multipurpose inventories and the county rural assessment role is only one of the uses for which soil surveys are made. We have long insisted that there is a need for only one basic soil survey and that the agricultural experiment stations, working with the Division of Soil Survey, U.S. Department of Agriculture, are best qualified to make such surveys.

Notwithstanding that there are a few of us who do not see eye to eye with the Soil Conservation Service and the Bureau of Reclamation on special purpose maps, we still believe that the Soil Conservation Service's land-use capability classes and the Bureau of Reclamation's susceptability for irrigation classes, can both be made from basic soil survey data without further field work and without the needless duplication that now takes place.

It is, however, not the purpose of this paper to criticize any other agency, but rather to explain just what we do to soil survey reports to make them of practical value to the county assessor.

A number of years ago a man named Keith was assessor in Riverside County. He asked us to show him how to use soil maps so that he could make an appraisal of soils which would compare in accuracy with those of houses and barns, cattle and crops. In other words, he wanted to know how to interpret soil-survey data for his own particular use. Incidentally, this same John Keith now heads the Division of Assessment Standards in the State Board of Equalization.

This request lead to the development of the method of soil rating now widely known all over the western hemisphere as the Storie-Index.

Storie-Index Rating. The theory back of the Storie-Index is that, if one knows (1) the profile characteristics of a soil, that is, the degree of weathering, or maturity: the presence of, and to what degree the *B* horizon has accumulated, clay or hardpan in secondary soils; and the depth to, and character of, the bedrock for primary soils; (2) the texture of the surface soil as a measure of water-holding capacity, ease of tillage, and the preparation of a seedbed; (3) the slope of the surface soil as a measure of ease of irrigation, influence on runoff, susceptability to erosion, etc., and (4) conditions of drainage, erosion, saline or alkali content, nutrient level, microrelief and acidity, he can make a fairly accurate prediction of what the soil is capable of in crop production.

The first three of these, which we call the *A*, *B*, and *C* factors, are permanent physical characteristics of a soil; the fourth, which we call the *X* factor, is, to a certain degree at least, subject to change by man or, in other words, a group of less permanent factors.

All of these characteristics of the soil are described in the modern, up-to-date soil survey report. If we know these characteristics we can put a value on them. The product of these separate values is the Storie-Index rating.

In the scheme of things there are nine major profile, or *A* factor, groups and these are further divided largely on the basis of depth of the surface soil. The most ideal profile condition is assigned a value of 100 per cent with decreasing values for less desirable conditions.

The nine profile groups and the breakdowns within the group and the per cent value assigned to each is set forth in Table 1.

The *B*, or surface-texture, factor is treated in a manner similar to the profile factor. There are five major texture divisions, each of which includes a more detailed texture breakdown.

Ideal textures are rated at 100 per cent and the less desirable textures at lower figures.

Table 2 shows the values assigned to the texture breakdowns. It should be remembered that the *B* factor refers only to the texture of the surface soil. Tte texture of the subsoil is a profile characteristic and has been considered in the *A* factor rating.

Factor *C*, slope, is treated similarly.

Table 3 shows the slope breakdown and the values assigned.

The several conditions listed under the *X* factor are treated independently. Usually only one is used but sometimes two

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Soil and Water Division.

The author: WALTER W. WEIR, drainage engineer, California Agricultural Experiment Station, Berkeley, Calif.

TABLE 1

Factor *A* — Rating on character of physical profile

	per cent
I. Soils on recent alluvial fans, flood plains, or other secondary deposits having undeveloped profiles	100
x - shallow phases (on consolidated material), 2 ft deep	50-60
x - shallow phase (on consolidated material), 3 ft deep	70
g - extremely gravelly subsoils	80-95
s - stratified clay subsoils	80-95
II. Soils on young alluvial fans, flood plains, or other secondary deposits having slightly developed profiles	95-100
x - shallow phases (on consolidated material), 2 ft deep	50-60
x - shallow phases (on consolidated material), 3 ft deep	70
g - extremely gravelly subsoils	80-95
s - stratified clay subsoils	80-95
III. Soils on older alluvial fans, alluvial plains, or terraces having moderately developed profiles (moderately dense subsoils)	80-95
x - shallow phases (on consolidated material), 2 ft deep	40-60
x - shallow phases (on consolidated material), 3 ft deep	60-70
g - extremely gravelly subsoils	60-90
IV. Soils on older plains or terraces having strongly developed profiles (dense clay subsoils)	40-80
V. Soils on older plains or terraces having harpan subsoils layers at less than 1 ft	5-20
at 1 to 2 ft	20-30
at 2 to 3 ft	30-40
at 3 to 4 ft	40-50
at 4 to 6 ft	50-80
VI. Soils on older terraces and upland areas having dense clay subsoils resting on moderately consolidated or consolidated material	40-80
VII. Soils on upland areas underlain by hard igenous bedrock at less than 1 ft	10-30
at 1 to 2 ft	30-50
at 2 to 3 ft	50-70
at 3 to 4 ft	70-80
at 4 to 6 ft	80-100
at more than 6 ft	100
VIII. Soils on upland areas underlain by consolidated sedimentary rocks at less than 1 ft	10-30
at 1 to 2 ft	30-50
at 2 to 3 ft	50-70
at 3 to 4 ft	70-80
at 4 to 6 ft	80-100
at more than 6 ft	100
IX. Soils on upland areas underlain by softly consolidated material at less than 1 ft	20-40
at 1 to 2 ft	40-60
at 2 to 3 ft	60-80
at 3 to 4 ft	80-90
at 4 to 6 ft	90-100
at more than 6 ft	100

TABLE 2

Factor *B* — Rating on basis of surface texture

	per cent
Medium-textured:	
very fine sandy loam	100
fine sandy loam	100
loam	100
silt loam	100
sandy loam	95
loamy fine sand	90
silty clay loam	90
clay loam	85
Heavy-textured:	
silty clay	60-70
clay	50-60
Light- or coarse-textured:	
coarse sandy loam	70-90
loamy sand	80
very fine sand	80
fine sand	65
sand	60
coarse sand	30-60
Gravelly:	
gravelly fine sandy loam	70-80
gravelly loan	60-80
gravelly silt loam	60-80
gravelly sandy loam	50-70
gravelly clay loam	60-80
gravelly clay	40-70
gravelly sand	20-30
Stony:	
stony fine sandy loam	70-80
stony loam	60-80
stony silt loam	60-80
stony sandy loam	50-70
stony clay loam	50-80
stony clay	40-70
stony sand	10-40

are required and, on rare occasions, as many as three will apply to some particular soil.

If two or more items are used they are multiplied. If all of the items listed under the *X* factor are 100 per cent, this figure appears only once, but whenever the value of any item is less than 100 per cent, it appears in the *X* factor column.

Table 4 shows the values assigned to each feature of the *X* factor.

When values have been assigned to each of the four factors, they are then multiplied — $A \times B \times C \times X =$ Index — and the resulting figure is the rating for the soil. It represents the percentage productivity that this soil bears to an ideal all-purpose soil. It should be noted that the Storie-Index rating considers only the physical characteristics of the soil and makes no distinction between soils under different environmental conditions. Also, that it is not a rating for any particular crop but for crops as a whole. Frequently the Storie-Index rating may not represent the true rating for a specific

TABLE 3

Factor *C* — Rating on basis of slope

	per cent
A — nearly level (0 to 2%)	100
AA — gently undulating (0 to 2%)	95-100
B — gently sloping (3 to 8%)	95-100
BB — undulating (3 to 8%)	85-100
C — moderately sloping (9 to 15%)	80-95
CC — rolling (9 to 15%)	80-95
D — strongly sloping (16 to 30%)	70-80
DD — hilly (16 to 30%)	70-80
E — steep (30 to 45%)	30-50
F — very steep (45% and over)	5-30

TABLE 4

Factor *X*—Rating of conditions other than those in factors *A*, *B*, and *C*

	per cent
Drainage:	
well-drained	100
fairly well drained	80-90
moderately waterlogged	40-80
badly waterlogged	10-40
subject to overflow	variable
Alkali:	
alkali-free	100
slightly affected	60-95
moderately affected	30-60
moderately to strongly affected	15-30
strongly affected	5-15
Nutrient (fertility) level:	
high	100
fair	95-100
poor	80-95
very poor	60-80
Acidity: according to degree	80-95
Erosion:	
none to slight	100
detrimental deposition	75-95
moderate sheet erosion	80-95
occasional shallow gullies	70-90
moderate sheet erosion with shallow gullies	60-80
deep gullies	10-70
moderate sheet erosion with deep gullies	10-60
severe sheet erosion	50-80
severe sheet erosion with shallow gullies	40-50
severe sheet erosion with deep gullies	10-40
very severe erosion	10-40
moderate wind erosion	80-95
severe wind erosion	30-80
Microrelief:	
smooth	100
channels	60-95
hogwallows	60-95
low hummocks	80-95
high hummocks	20-60
dunes	10-40

crop but with the wide experience that Mr. Storie and his associates have had with California soils and hundreds of production figures on different soils under the same environmental conditions the figures are found to be very close to actual relative values. One very important thing to remember in rating soils is that the better one knows a soil, the more one knows about its characteristics, the closer it can be rated.

Natural Land Type Classification. There is another important classification which we have developed for California soils and which we believe adds materially to the understanding of the soil and its rating. I refer to the natural land division. This is a classification in which the landscape or the topographic position of the soil is considered. It has been found that the rating, taken alone, gives only an indirect clue to where a soil lies with respect to other soils in the general landscape picture. The natural land division classification should be used in conjunction with the Storie-Index rating.

The natural land classification divides soils in five major groups: A, alluvial fan and flood plain soils; B, basin soils; C, lower terrace soils; D, higher terrace soils, and E, upland soils. Each of these groups is further divided on the basis of surface texture and subsoil density, slope, and depth to bedrock. Table 5 shows in an abbreviated form the items considered in this classification.

Each soil type that is shown on our maps has a natural land division symbol as, for example, B4-1p or E5. This is a descriptive legend. B4-1p means a secondary or alluvial soil occupying basin position, having a heavy textured surface soil and a moderately dense subsoil, and poor drainage. E5 means a primary or upland soil of medium surface texture, less than 2 ft deep and on rolling topography.

The soils in every soil survey area are grouped by natural land divisions and within any one division are arranged alphabetically by series name before the final map symbol is assigned.

Soil Inventory. All of the important soil characteristics are tabulated in what we call the soil inventory. This is the most important step in the entire procedure. The county assessor, upon receipt of this table, finds it an easy matter to compare the different soils. Table 6 shows the headings of the various columns of the soil inventory under which have been placed the information on several soils taken at random from the Colusa County report. The soil data set up in the manner shown on these inventory sheets has become so popular with those who are trying to make practical use of soil surveys that the University of California is now publishing its own soil survey reports in an atlas form. The soil inventory sheets are a major part of the text. These atlases are 11 x 17 in in size (twice the size of an ordinary typed page). The maps, on a 2-in-per-mile scale, are cut up into sheets to fit this size of page. We try to put a half township on a page, but this is not always possible because a large part of the agricultural lands are not sectionized and county lines usually follow topographic or other natural boundaries. We can publish this type of report within about one year after the field work is completed and thus be

(Continued on page 492)

TABLE 5. NATURAL LAND DIVISIONS

(Abbreviated description)

A Alluvial fan Surface texture subsoil density	B Basin Surface texture subsoil density	C Low terrace Surface texture subsoil density	D High terrace Surface texture subsoil density	E Upland Surface texture depth + slope
1. M/deep perm.	1. M/deep perm.	1. M/deep perm.	1. M/deep perm.	1. M/>2′; roll.
2. M/mod. dense	2. M/mod. dense	2. M/mod. dense	2. M/mod. dense	2. H/>2′; roll.
3. H/deep perm.	3. H/deep perm.	3. H/deep perm.	3. H/deep perm.	3. L/>2′; roll.
4. H/mod. dense	4. H/mod. dense	4. H/mod. dense	4. H/mod. dense	4. St/>2′; roll.
5. L/deep perm.	5. L/deep perm.	5. L/deep perm.	5. L/deep perm.	5. M/<2′; roll.
6. L/mod. dense	6. L/mod. dense	6. L/mod. dense	6. L/mod. dense	6. H/<2′; roll.
7. Gr/deep perm.	7. Gr/deep perm.	7. Gr/deep perm.	7. Gr/deep perm.	7. L/<2′; roll.
8. Gr/mod. dense	8. Gr/mod. dense	8. Gr/mod. dense	8. Gr/mod. dense	8. St/<2′; roll.
9. M/hardpan	9. M/dense clay	9. M/dense clay	9. M/dense clay	9. M/>2′; steep
10. H/hardpan	10. H/dense clay	10. H/dense clay	10. H/dense clay	10. H/>2′; steep
11. L/hardpan	11. L/dense clay	11. L/dense clay	11. L/dense clay	11. L/>2′; steep
12. Gr/hardpan	12. Gr/dense clay	12. Gr/dense clay	12. Gr/dense clay	12. St/>2′; steep
13. Gr/Gr	13. M/hardpan	13. M/hardpan	13. M/deep perm; slpg.	13. M/<2′; steep
14. Misc. nonagr.	14. H/hardpan	14. H/hardpan	14. M/mod. dense; slpg.	14. H/<2′; steep
	15. L/hardpan	15. L/hardpan	15. H/deep perm; slpg.	15. L/<2′; steep
	16. Gr/hardpan	16. Gr/hardpan	16. H/mod. dense; slpg.	16. St/<2′; steep
	17. Misc. nonagr.	17. Misc. nonagr.	17. L/deep perm; slpg.	17. Misc. nonagr.
			18. L/mod. dense; slpg.	
			19. Gr/deep perm; slpg.	
			20. Gr/mod. dense; slpg.	
			21. M/dense clay; slpg.	
			22. H/dense clay; slpg.	
			23. L/dense clay; slpg.	
			24. Gr/dense clay; slpg.	
			25. M/hardpan	
			26. H/hardpan	
			27. L/hardpan	
			28. Gr/hardpan	
			29. M/hardpan; slpg.	
			30. H/hardpan; slpg.	
			31. L/hardpan; slpg.	
			32. Gr/hardpan; slpg.	
			33. Misc. nonagr.	

Modifying factors		Textures
−1p	poor drainage	L — light
−1o	overflow	M — medium
−2s	slight alkali	H — heavy
−2m	moderate alkali	Gr — gravelly
−2a	strong alkali	St — stony
−3s	slight erosion	
−3m	moderate erosion	
−3mb	moderately severe erosion	
−3b	severe erosion	
−4f	fair nutrient level	
−4p	low nutrient level	
−5h	hogwallow microrelief	
−5d	dune microrelief	
−5ch	channelled	

TABLE 6. SOIL INVENTORY — DIVISION OF SOILS, UNIVERSITY OF CALIFORNIA, COLUSA COUNTY AREA

Natural land division	Soil symbol	Soil designation	Characteristics: Stable: Profile group	Soil reaction	Color of surface soil	Parent material	slope	Drainage surf/sub	Alkali	Less stable: Erosion	Nutrient level	Micro-relief	Soil rating: A Profile	B Texture	C Slope	Other X conditions	Storie-index	Grade
A1	5	Columbia silt loam	I	neut	lt gr br	mix all	A	E/E	O	O	E	sm	100	100	100	100	100	1
A1	19	Arbuckle sandy loam	II	sl acid	lt yel br	sed all	A	E/G	O	O	G	sm	95	95	100	95	86	1
A1-2m	26M	Colusa clay loam	I	calc	lt gr br	mix all	A	F/P	M	O	F	ch	100	85	100	80x40x80	22	4
B2-1f	101	Marvin clay loam	III	calc sub	lt gr br	mix all	A	F/P	O	O	G	sm	85	85	100	80	58	3
C9-2s	130S	Antoine loam	IV	alk	gr br	sed all	A	P/P	S	O	P	sm	50	100	100	75x75	28	4
D12-3m	143	Corning gravelly loam	IV	sl acid	rd br	mix mar	D1D	X/R	O	mod	P	var	40	85	70	85	20	4
E2	150	Forgeus clay	IX	neut	choc br	sed rks	CC	G/G	O	O	G	sm	80	60	80	100	38	4
E16	228	Henneke stony clay loam	VII	neut	dk rd br	serp rks	F	X	O	sev	P	sm	25	80	40	85x50	3	6

Breeding and Adapting Cotton to Mechanization

By George J. Harrison

A FEW years ago it was a common feeling that it might be necessary to change the conformation of the cotton plant in order to do a suitable job of picking cotton with the spindle-type harvester as it now exists. It may be that such a change is desirable, and certainly at the U.S. Cotton Field Station, Shafter, Calif., considerable effort is being expended to this end. But such modification by breeding methods may require 5 to 10 years with good fortune. In the meantime, more farmers are relying heavily on the machine for the harvesting of their crop. In fact, the chief limiting factor in the use of the cotton-picking machine in California is the inability of the manufacturers to fully meet the demand for machines. Although the present use of these machines is unquestionably economically profitable, the amount of trash gathered and the amount of cleaning of cotton now required for removal of trash is costing the farmer as well as the processors of cotton entirely too much.

The genetic composition of the cotton plant is highly complex. This is brought about not only by the large number of chromosome pairs (26 pairs in the American upland species, *Gossypium hirsutum*) but also by the origin of the chromosomes. Thirteen pairs, or one genome, are similar in origin to the Asiatic cotton, whereas the other genome of thirteen pairs of chromosomes have an origin similar to that of American wild cottons.

In a breeding program designed to modify the factors which contribute to the economic uses of the crop, the cotton breeder must be consciously concerned with more than forty characters of plant, fiber and of the finished product. The odds against getting all the desired ones together in a single variety are infinite. Some characters are obvious and easy to measure, some are microscopic and intangible, and still others so far can be evaluated by comparison only. Few known characters are inherited in a simple manner, and these are seldom of economic importance, or if so they may be of a deleterious nature. It often happens that the most desirable fiber properties are linked with objectionable plant characters such as weak stalks or small bolls. These linkages can and have been broken, but most often it requires time, patience and an immense amount of detailed effort.

If given ample space and favorable environment the cotton plant will consist of a main axis, more or less perpendicular, with fifty or more lateral branches. These laterals are of two types commonly called fruiting and vegetative branches. Morphologically the vegetative type may be considered as secondary stalks since they too produce fruiting branches. The development of vegetative branches is very largely dependent upon local environment such as spacing, soil fertility, moisture and insect control. Inherently they develop erect or parallel to the main axis, at an angle or roughly 45 to 60 deg, or at right angles, which places them in a horizontal position, if not actually on the ground at maturity. Of the three branching habits only the vertical is entirely satisfactory where late cultivation and machine picking are contemplated. Ironically enough the most objectionable, horizontal habit is often associated with the most desirable fiber properties. This association can and has been broken by breeding methods without the loss of the desired fiber quality, but it can best be controlled by close spacing of plants in the row, by proper soil fertility and timely insect control.

The fruiting branches are formed at regular intervals throughout the height of the plant and their position is nearly at right angles to the main axis. These branches consist of from one to several nodes, depending on local conditions, and ideally form a boll at each node, each branch being subtended by a leaf at its base and each node producing a leaf as well as a fruit. If given ample space some of these branches will form at or near the ground level, and thus produce some bolls that will be inaccessible to any current spindle-type harvesters. Over a period of years it has been demonstrated at Shafter that 12-in spacing of plants within rows 40 in apart will allow the first bolls to be formed at about the 2-in level, whereas 4-in spacing forces the first bolls to develop at about 6 in in height. Some varietal or strain differences have been found in this respect, the more rank-growing varieties tending to form their first bolls at a slightly higher level when plants are more crowded in the row. The tendency is toward slightly higher yields and earlier maturity with closer spacing such as 2½ in.

At some time in its development all portions of the cotton plant of the American upland type are covered with rather short hairs. These hairs may be simple (straight), but commonly they are stellate in shape. They may be deciduous, but are most likely to persist, depending upon the variety of cotton. Their density is of importance in removing leaf and similar trash from the harvested cotton; sparseness and hairs of the simple type promote ease of removing trash by the usual methods. Among varieties, there is wide variation in the density, persistence and shape of these hairs. Within the species there seems little likelihood that varieties can be developed that will be entirely devoid of hairs. However, varieties can and will be develped, in the not too distant future, that will have so relatively few hairs as to render them of much less importance.

The objection to these hairs on the vegetative parts of the cotton plant lies in the fact in harvesting and otherwise handling of the unginned cotton, the leaves and bracts become crushed and enmeshed with the fibers. Once this has happened, nothing short of combing will remove all the trash particles. This problem has long been recognized by the cotton breeders, but its full impact upon the grades or quality of cotton was not fully appreciated until the advent of the cotton-picking machine and the simultaneous deterioration of the quality of hand picking about 1943.

The cotton fiber, regardless of length, consists of a single cell composed primarily of cellulose. Elongation begins at the time the flower opens and continues for 18 to 21 days. At this stage it consists of a very thin, transparent membrane which forms the outer walls. For the next 20 days or thereabout the further development of the fiber is concerned with secondary thickening, or the deposition of additional cellulose within. Anderson and Kerr in North Carolina have demonstrated with photomicrographs that the additional cellulose is laid down in daily increments, a lesser amount being laid down during the hours of darkness thus giving the effect of daily growth rings quite comparable to the familiar annual growth rings of forest trees. Moreover, they demonstrated that if the fiber developed under continuous light the daily rings were absent, thus giving the fiber the appearance of a solid filament except for the hollow center.

Within a variety, heredity determines the amount of secondary thickening which can take place. On the other hand, environmental factors such as light, temperature, soil fertility, soil moisture and age of the mother plant may contribute much. Secondary wall thickening is important to mechanical harvesting of cotton to the extent to which it contributes to the ease of cleaning. A fully developed fiber is more or less circular in cross section, but a poorly developed one, when dry, collapses in proportion to the amount of cell-wall development. Undeveloped fibers more readily become enmeshed in the leaf trash accumulated from the plant and thereby contribute their pro rata of difficulty in cleaning at the gin and otherwise cause trouble even in the dye vat of the finished product. The longer and finer the fiber, whether from

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inheritance or environment, the more difficulty is likely to be experienced in all processing operations including acceptable mechanical picking. Conversely, the shorter, coarser and more fully developed the fiber, the more successfully they can be processed.

Lest you wonder why the industry does not simplify its problems by producing the short, coarse cottons, let me make it clear that there are many uses for cotton and no one or several staple lengths will serve all these purposes. The American spinning industry uses cottons ranging in staple length from 13/16 to 1½ in and longer. The longer the staple, the finer it is likely to be, and the more important it is that it be evenly processed and reasonably free of foreign matter.

A breeding program which contemplates all phases of cotton mechanization must first include the matter of prompt seedling emergence after planting. While this is governed to a large degree by environment, inheritance plays an important role. It has been found that under practically ideal conditions of moisture, temperature and every other factor which contributes to prompt emergence, there are wide varietal differences in the length of time required for germination and seedling emergence. These differences at Shafter in 1951 amounted to as much as 10 days. Since all controllable factors were considered equal, it can safely be said that the differences are inherited. Moreover, fourth and fifth-generation inbred crosses between the extremes, prompt and delayed emergence, when planted under like conditions strongly tended to be like one or the other of the parents.

Seedling vigor although less conspicuous is likewise an inherent character. Neither prompt emergence nor seedling vigor is necessarily correlated with total yield or date of maturity so far as has been observed by the speaker. Their importance appears to be largely in a matter of early effective weed control in that they permit cultural practices to be initiated more promptly. Effective weed control is one of the most important aspects of cotton mechanization. This can best be done with prompt emergence of vigorous cotton seedlings which allows weeds to be destroyed before they become established.

CONTROL OF SEEDLING DISEASES IMPORTANT

The control of seedling diseases is most important in a cotton mechanization program. Fairly dense, continuous stands go a long way in the suppression of late weeds, but they are highly essential for the smooth, efficient operation of the spindle-type cotton picker especially. Seedling diseases in a well-balanced rotation program involving cotton probably contribute more to irregular stands than any other single cause. At the present there is nothing more than a strong indication that resistance to these diseases does exist in American cottons. In view of its importance to mechanization no cotton breeder can any longer afford to ignore any possibility of such resistance. Fortunately in California we are concerned with only one such disease so far as is known, and there are only occasional seasons and conditions in which its devastations are extensive.

For suitable performance of the mechanical picker cotton should not exceed about 5 ft in height, although it can be efficiently picked up to a height of 6 ft. To be picked well at these heights the plants must be erect or nearly so. To carry a crop of three bales per acre or more inherent sturdiness is a prerequisite. This can and has been attained in a number of varieties, but no variety to my knowledge has yet been developed that will carry such a load and remain erect to maturity unless the crop be well distributed over the plants. In order to get a well-distributed crop, insect control must be timely and effective. With high plant populations necessary for best picker performance, the plants must be fairly open in growth habit and total leaf surface must be held to the minimum for plant efficiency in order to allow penetration of insecticides.

In this regard two new but advanced strains developed by hybridization are under observation. One may be considered as intermediate in openness of plant habit, the other as extreme. Both have long first internodes on the fruiting branches and long leaf petioles, particularly those subtending the fruiting branches at the main axis. The leaves are deeply cupped, giving them the appearance of being smaller than they actually are. Few limbs develop even with wide spacing and high soil fertility. The more open type has fiber of better than average quality; the intermediate one has fiber of superlative quality in every measurable character. Both have been found to allow penetration to the ground of sunlight, insecticides and defoliants, even when they attain a height of 6 ft. Whether or not their yielding capacity is sufficient to encourage commercial production remains to be demonstrated, but without doubt they do point to at least a partial solution of some of the problems of mechanical picking. By the end of the current season some information will be available on the cleaning and ginning properties of the intermediate form.

Some cotton breeders have seemed to feel that boll size is important to mechanical picking, being inclined to favor those of moderate dimensions. In a study of the efficiency of the spindle-type picker in recovering the available cotton from the plant on approximately 200 progeny rows each year since 1948, boll size to us has not seemed important. In this study the boll size has ranged from 45 to 80 per pound of seed cotton. Actually the best recovery observed to date was in 1949 from a strain designated as 57-3, having an average boll size of 46 per pound. Here no better job could have been done by hand gleaning. The worst job observed was in an adjoining row in a strain of Acala designated as 5-12 which has an average boll size of 52 per pound. In both rows the plants were about 4 ft tall, erect, few side limbs and otherwise similar in conformation.

BOLL CONFORMATION DETERMINES PERFORMANCE

So far as our experience is concerned the conformation of the boll largely determines how well the spindles will perform the task of recovering the cotton. In the two strains cited above, the good recovery was from bolls having relatively smooth inner surfaces when dry, the burs straight, approximately equidistant one from the other with the cotton protruding far enough to afford good contact by the spindles, but set deeply enough into the carpels to provide reasonable storm resistance. On the other hand, poor picking qualities were associated with badly rugose inner walls of the carpels that were extremely gnarled with seldom any two being parallel. The tendency to straight, parallel opening of the burs is a varietal character as is also the tendency to gnarl, and it is easy to select and develop either extreme. But lest you misunderstand, the gnarled opening of the burs of any variety may be induced by unfavorable environment. A deficiency of soil moisture is perhaps the most common cause of defective picking of an otherwise satisfactory variety. This applies to hand as well as machine picking.

The time and uniformity of maturity of the crop are of considerable importance in cotton harvesting. To some extent these are heritable characters. They are governed by the ability of the variety to develop rapidly and to retain its crop as it progresses, in other words, inherent vigor. In nearly all cotton growing areas of the United States weather determines to a large extent when the harvest shall be and what the quality may be within the limits of the variety. In order to attain highest quality cotton, maturity should be so timed that the major part of the crop at least can be harvested in periods of the most prolonged dry weather. This is an absolute necessity for machine picking, since it is impossible to operate the spindle-type picker when there is any appreciable amount of free moisture on the cotton. Even if the machines could be made to function, the fiber would be so damaged as to materially impair its value. Neither the breeder nor the grower can at all times anticipate correctly seasonal fluctuations in the period of most favorable conditions. Both can take advantage of seasonal averages over a period of years and may reasonably expect crop maturity to coincide more generally with favorable weather.

In California with the development of Acala 4-42 and its universal use, we have increased the earliness of the harvest season by 10 days in the more arid, high-temperature zone and to as much as 30 days in the more northern areas where weather is generally less favorable. Part of this shift has been

due to the more rapid development of the strain and part to the fact that farmers largely adopted recommended irrigation and fertilization practices. Prompt, uniform maturity which is so essential to machine picking, is dependent to very large extent on rapid, continuous development of the plant. Constant, ample moisture combined with sufficient fertility from the beginning are essential. Of course, it is not always possible to control moisture, but any added fertilizer, particularly nitrogen, should be gauged to the actual needs of the crop and applied so as to be consumed by the time the crop is mature. Nitrogen is well known to delay maturity and if used to excess or too late in the season serves to produce excess vegetation and thereby adds to harvesting problems. This may be doubly true if defoliation is contemplated.

That insects show varietal preference is no longer open to doubt. There are probably exceptions, but it has been the experience at Shafter that such preference is exhibited only so long as they have opportunity to choose. In that area only one strain of cotton is permitted by state law for commercial use. Public agencies such as the experiment station are not bound by this law for experimental purposes. As soon as an unpalatable strain is put into commercial production, the insects which showed a distaste for it while in the experimental plots at the station continued their feeding habits as if no change had been made.

While it is not intended to rule out the possibility of developing cottons for economic use that will prove less attractive to the insects than at present, in the light of experience thus far gained, the chances seem remote. Undoubtedly the insect population of many regions have been compelled by availability of host plants to modify their feeding habits, and have learned to thrive under the enforced changes. Much of the irrigated west is recent enough in its agricultural development that many of us still living in the region have seen several insect species change their habits from a meager survival on such vegetation as the varying seasons provided to thriving hordes of vast economic importance. The several species now important to cotton production in the region have been among the most versatile in changing their feeding habits. Likely they could do so again if necessary.

Therefore, in the main at least, the cotton grower must continue to rely on chemicals as a means of insect control. A lack of control even though a good crop can still be grown in many areas, may prove as important to satisfactory mechanical harvesting as any aspect of the job.

TIMING IMPORTANT IN INSECT CONTROL

For best results one of the most important aspects of insect control is the timing. In cases of full yields in any variety of cotton it is essential that the crop be well distributed over the plants if lodging is to be avoided. Through many years of cotton breeding and agronomic research it has become evident that in a well-balanced crop, up to four bales per acre and more, the plants do not lodge and do not grow excessively large. On the other hand, much lighter crops that are poorly distributed over the plants often result in severe lodging even of the most sturdy varieties. In general, in order to attain maximum yields without excessive plant growth, it is imperative that the first bolls developed be retained. Failure to do this, providing there is ample soil moisture and fertility, the plants will be forced into vegetative growth that henceforth will be difficult to suppress without impairment of yield and perhaps quality of fiber. Moreover, such failure is very conducive to subsequent development of late vegetative limbs and axillary bolls which will be late maturing. In extreme cases of Hemipterous insect injury fruiting branches may be reduced to a single node or destroyed, thus adding to the unbalancing of the plant. When this happens, it is not uncommon for the more vigorous varieties to produce vegetative limbs near the top, or for the fruiting branches to be transformed into limbs. All such misplaced development adds to the difficulty of picking in general and to mechanical picking in particular.

As machine harvesting increases, the more imperative becomes good defoliation, because of the added cleaning burden which is placed upon the gins. With chemicals now available, it is still to be demonstrated that one variety of cotton is any easier to defoliate than any other. In the light of our present knowledge there seems little that the cotton breeder can contribute to the problem of defoliation beyond plant sturdiness and other habits of growth and maturity. Ideally, crop maturity and defoliability should coincide. In actual practice these two stages of development do not always occur together. It may be that they are more likely to coincide in one variety than another, but so far the ability to recognize the conditions of good defoliability is limited. Somehow the grower must learn to recognize this condition in his crop and be prepared to act promptly when it arrives. New or second growth is an ever-present hazard to premature defoliation and because of it the harvest should follow close behind the abscission of the leaves.

Just as a cotton grower who contemplates machine picking must begin laying his plans to this end with seedbed preparation, also should plans for defoliation begin at the same time. High areas of the field should be planed off and low ones filled. In no case should excess water be allowed to accumulate on the field even if pump drainage is necessary. Fertilizers, if used, should be applied so as to produce uniform growth and maturity throughout. It is fully appreciated that soil texture is a fixed thing and any variation therein contributes to the problem of defoliation of cotton. To a very large extent such variation can be alleviated by judicious use of fertilizers and in the irrigated region by differential application of water. Alkali or saline areas should be mapped and correctives added, preferably in winter, but experience has demonstrated that these can be effectively added during the growing season.

There is some evidence being accumulated that defoliability of cotton at maturity is correlated with the life history of the plants. Fields or portions of fields which have suffered intermittently for soil moisture or other deficiencies that contribute to irregular development, are more likely to be difficult to defoliate even with favorable circumstances at maturity.

SUMMARY

Genetically cotton is highly complex and linkage of desirable and undesirable characters is common. This makes improvement along many desired lines difficult and tedious.

Morphologically the cotton plant consists of a main axis with fruiting and vegetative branches. The vegetative branches are subject to suppression by cultural practices. Under many circumstances the fruiting branches may develop at or near the ground level, but by increasing the plant population per acre they may be forced to develop several inches higher. This is desirable for good recovery by the mechanical picker.

The plants of American upland cotton are covered with short hairs, simple or stellate, of varying density. These hairs are important from the standpoint of removing the trash from the lint. The fewer and more nearly simple the hairs the more easily the trash can be removed.

The cotton fiber consists of a single cell composed primarily of cellulose. These cells elongate for 18 to 21 days after the flower opens and require a like period in addition for full development of the fiber walls. As a rule the shorter and coarser the fiber, the more easily they can be processed. Underdeveloped fibers are more likely to be troublesome in all processing operations.

Continuous, fairly dense stands of cotton are essential to best performance of the spindle-type picker. Such stands are difficult to maintain without control of seedling diseases. Desirable crops rotations are conducive to seedling diseases of the soil-borne type. The best remedy for this lies in the development of resistance by breeding methods; to date, so far as is known, the cotton breeders have little to offer in this regard.

For best use of the mechanical picker, cotton plants should be erect, sturdy and of growth habits that permit penetration of insecticides and defoliants. Two new strains having these habits are under study at Shafter, Calif., one extremely open in growth, the other is intermediate. Both allow better than average penetration of sunlight and chemicals.

The conformation of the open *(Continued on page 492)*

Cotton Mechanization Studies in California

By J. R. Tavernetti and B. B. Ewing
MEMBER ASAE ASSOCIATE MEMBER ASAE

COTTON was grown in California as early as 1860, but it was not until 1914 when about 50,000 acres were planted that it became of much economic importance. Although there were yearly fluctuations, betwen 1914 and 1938 acreage gradually increased to approximately 325,000 at which it remained until 1946, thereafter increasing rapidly to a peak of 950,000 in 1949. In 1950, a decrease to about 600,000 acres occurred because of government controls, but in 1951 with the controls removed it is estimated there will be in the neighborhood of 1,300,000 acres planted (Fig. 1). Over 95 per cent of the acreage in the past 10 years has been in six of the 58 counties of the state which are located in the southern end of the San Joaquin Valley.

Although in the past 10 years the yield has varied between 500 and 700 lb of lint per acre, in 1950 it reached an all-time high of 805 lb. The total value in 1949 and 1950 was the highest of all field crops grown in the state. In 1949 it was valued at $202,000,000 and in 1950 at approximately $240,000,000. In 1951 it is estimated that at present prices the value will be well over $300,000,000.

Field labor required for growing and harvesting the crop varies according to the time of year, with a peak for thinning and hoeing in June and another peak for harvesting in November. Fig. 2 shows the number of hand laborers employed during 1948 when there were 800,000 acres of cotton grown. During that year between 5 and 10 per cent of the crop was picked by machine.

Limited investigations of cotton mechanization in California were made between 1928 and 1932, but since 1946 an intensive study has been conducted. Headquarters have been at the U.S. Cotton Field Station at Shafter since 1949, and the work has been a cooperative project between the agricultural experiment station of the University of California and the Bureau of Plant Industry, Soils and Agricultural Engineering, U.S. Department of Agriculture. The California Agricultural Extension Service and the California Planting Cotton Seed Distributors have also cooperated.

The work has consisted of (1) plant breeding to develop characteristics which are more suitable for mechanization, particularly harvesting; (2) cultural practices to eliminate or mechanize thinning and weed control, and to improve mechanical picking; (3) observations and improvement of equipment adaptable to cotton growing, and (4) testing of chemicals for weed control and defoliation.

The cotton for the tests described, unless otherwise indicated, was grown on beds in sandy loam soil with 40-in row spacing. Acid-delinted seed was planted the first part of April at the rate of 22 lb per acre, and 80 lb of nitrogen in the form of ammonium sulphate was drilled into the soil when planting. Furrow irrigation was begun about June 1 and was continued at one to two-week intervals until the first part of September. All picking was done with an International M12H picker, starting the first part of October and ending the latter part of November. The following is a summary of the results obtained:

Plant Population Studies. These studies were to determine the effect of the number of plants per acre as obtained by different thinning methods on yield, lint quality, and adaptability to mechanical harvesting.

Results of the tests conducted the past two years to determine the effect on yield are shown in Table 1. With hand thinning, there was practically no difference in yield when the population was 19,000 or more plants per acre or when the spacing was 8 in or less between plants. There was, however, a decrease in yield when the plant population was 15,000 or less per acre or when the spacing was 10 in or more between plants. With drilling to a stand, except for one test, the yield was not affected when the plant population was 28,000 or more plants per acre but decreased when it was 23,000 or less. The 1949 test and test 1 in 1950 were at the Shafter Experiment Station on sandy loam soil, while tests 2, 3 and 4 in 1950 were on selected farms with sandy, sandy loam, and clay loam soils, respectively. When mechanically chopped, the yield seemed to vary with the plant population, but more tests are needed to draw definite conclusions. From the results of all the tests for the two years, the general conclusion may be drawn that, if the plants are uniformly spaced as in hand thinning, the plant population may be as low as 20,000 per acre, or one plant every 8 in without materially decreasing yield. However, when drilled to a stand or mechanically chopped, greater plant populations are necessary because of less uniform distribution.

The effect of plant population on the height of the first fruiting node is shown in Table 2. The height was determined by measuring from the ground surface at the base of the plant up the main stalk to the first branch containing fruit. Although there were differences between the various

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AUTHORS' NOTE: Credit for the experimental work on cotton mechanization in California prior to 1950 is given to J. P. Fairbank, formerly associate agricultural engineer in the experiment station, University of California, and K. O. Smith, associate agricultural engineer, (BPISAE), U.S. Department of Agriculture, now on military leave. Credit is also given to George Harrison and E. Gordon Smith, USDA Cotton Experiment Station (Shafter), for their help and cooperation in carrying on the work.

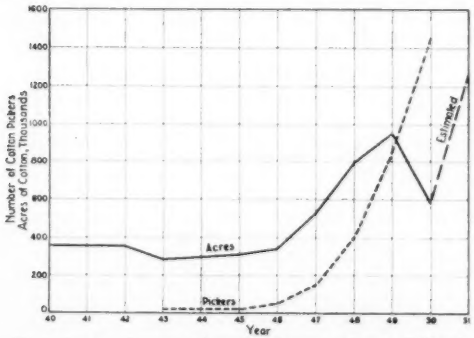

Fig. 1 Acreage of cotton and number of cotton pickers in California

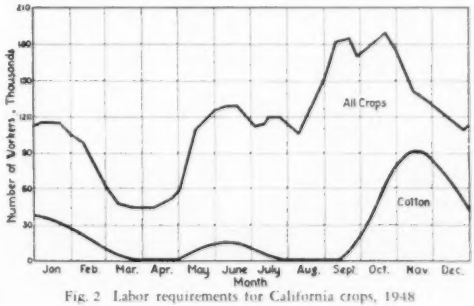

Fig. 2 Labor requirements for California crops, 1948

TABLE 1. EFFECT OF PLANT POPULATION ON YIELD

Plants per acre, thousands	Average plant spacing, in	Yield, bales per acre: Hand thinned 1949	Hand thinned 1950	Drilled to stand 1949	Drilled to stand 1950 Test 1	Drilled to stand 1950 Test 2	Drilled to stand 1950 Test 3	Drilled to stand 1950 Test 4	Mechanically thinned, 1950
78.4	2.0	——	2.86	——	——	——	——	——	——
45-60	2.6-3.5	——	——	2.75	2.64	1.84	2.70	2.28	2.92*
28-39	4.0-5.6	2.76	2.64	2.74	2.74	1.76	2.87	2.12	2.79†
19-23	6.8-8.2	2.85	2.73	2.60	2.44	——	2.82	1.87	2.63‡
13-15	10.5-12.0	2.52	2.52	2.53	2.34	1.68	2.51	1.88	——
9-10	15.7-17.4	2.25	——	——	——	1.28	——	——	——

*Average of two plots, both 2.92.

†Average of three plots ranging from 2.72 to 2.86.

‡Hand-thinned check plot with 23,600 plants per acre yielded 2.84 bales per acre.

tests, in all cases the height was greatest with the largest plant population and decreased as the population became less.

The effect of plant population on the picking efficiency of the mechanical harvester is shown in Table 3. The efficiency was determined by hand gleaning three 10-ft sections of each row in the plots. While there was some trend toward higher picking efficiencies with the larger plant populations, the results are inconsistent and the differences so slight that no definite conclusions can be drawn.

TABLE 2. EFFECT OF PLANT POPULATION ON HEIGHT OF FIRST FRUITING NODE

Plants per acre, thousands	Average plant spacing, in	Height of first fruiting node, in: Hand-thinned 1949	Hand-thinned 1950	Drilled to stand 1949	Drilled to stand 1950 Trial 1	Drilled to stand 1950 Trial 2	Drilled to stand 1950 Trial 3	Drilled to stand 1950 Trial 4
78.4	2	——	10.1	——	——	——	——	——
45-60	2.6-3.5	——	——	6.3	7.3	7.5	10.4	7.3
28-39	4.0-5.6	6.8	8.5	4.8	6.4	5.2	8.1	5.7
19-23	6.8-8.2	3.6	6.6	3.9	5.2	——	6.7	4.5
13-15	10.5-12.0	2.7	5.9	3.6	3.8	4.6	5.1	2.0
9-10	15.7-17.4	2.0	——	——	——	3.3	——	——

The effect of plant population on the trash content and grade is shown in Table 4. The trash content did not follow a definite pattern, but it is significant that the greatest population resulted in the highest trash content and the smallest population in the lowest. This can be partially explained by the fact that the heavy plant population had a more dense and somewhat taller growth and that defoliation was not as good as in the lighter stands. The latter was particularly noticeable in the lower portions of the plants. The defoliant used was sodium cyanamid dust applied by airplane. Although there was little difference, the grade of the cotton from the lowest plant population seemed to be slightly higher than the others. Staple length (1-1/16 in) and color (extra white) was the same for all tests.

Continuous Drilling versus Hill Dropping. In the tests of drilling to a stand, plots were included that were hill-dropped at the same seeding rate as would give an average plant spacing of 3 to 4 in with continuous drilling. A rotary-valve attachment to the regular planter was used for the hill dropping. The hills were spaced 14 in apart in 1949 and 12 in in 1950, and had 3 to 5 seeds per hill. Table 5 shows a comparison of the results obtained. The yield with hill dropping was less than with continuous drilling having the same plant population and was comparable to a continuous planting with about 60 per cent as many plants per acre. The height of the first fruiting node, picker efficiency and trash content were similar to continuous drilling with the same number of plants. From the results of these tests there seems to be no advantage in hill dropping.

Mechanical Thinning Trials. In this test thinning by six different makes of choppers was compared with hand thinning. The machines used were both ground- and power-take-off-driven types with both rotary and oscillating choppers. No attempt was made in these trials to set the choppers to give the same length of gaps and hills. Table 6 gives the results obtained. These results indicate that the yield is a function of the plant population after thinning rather than any effect of the type of chopper used. There is no indication that one chopper gives better results than another provided they leave the same number of plants per acre. They also show that mechanical thinning can be done without affecting yield, but that it is necessary to leave a greater plant population than with hand thinning.

Weed Control. Weed control is one of the main obstacles to the complete mechanization of cotton growing in California. Weeds may affect not only the yield but also mechanical harvesting by lowering the grade and the picking efficiency. Tests have been conducted using chemicals, flame and mechanical methods with varying results.

Chemical weed control using a variety of materials both as preemergence and postemergence sprays was tried during 1950. For the preemergence tests the materials were applied two days before emergence of the plants. The materials used were an oil emulsion fortified with sodium P.C.P. (pentach-

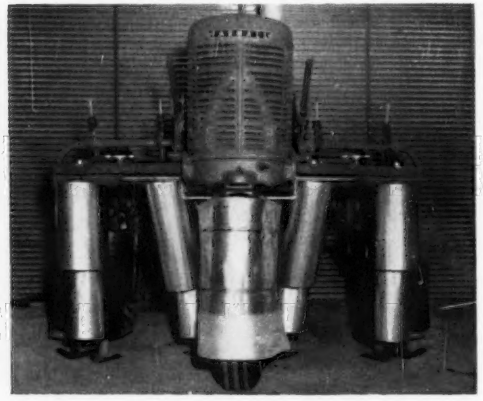

Fig. 3 High-clearance tractor equipped with shields for late cotton cultivation

TABLE 3. EFFECT OF PLANT POPULATION ON PICKER EFFICIENCY*

Plants per acre, thousands	Average plant spacing, in	Picker efficiency, per cent: Hand thinned 1949	Hand thinned 1950	Drilled to stand 1949	Drilled to stand 1950	Mechanically thinned 1950
78.4	2.0	——	97.1	——	——	——
45-60	2.6-3.5	——	——	96.2	94.5	96.1-96.5
28-39	4.0-5.6	97.4	95.8	95.6	92.2	95.7-96.0
19-23	6.8-8.2	97.4	95.6	95.3	93.1	95.0†
13-15	10.5-12.0	97.1	94.4	95.6	92.0	——
9-10	15.7-17.4	95.1	——	——	——	——

*Picker efficiency is the total for two pickings.

†Hand-thinned check plot with 8-in spacing was 96.0 per cent.

TABLE 4. EFFECT OF PLANT POPULATION ON TRASH CONTENT AND GRADE OF FIRST PICKING COTTON IN 1950

Plants per acre, thousands	Average plant spacing, in	Hand-thinned					Drilled to stand		
		Trash, %	Grade*				Trash, %	Grade†	
78.4	2.0	5.7	M	M	M	SM			
45-60	2.6-3.5	—	—	—	—	—	6.9	M	M
28-39	4.0-5.6	4.8	M	M	M	M	5.6	M+	M
19-23	6.8-8.2	5.2	M	M	M	M	6.1	M	M
13-15	10.5-12.0	4.3	M	SM	M+	M	4.1	SM	M

*Four replicates. †Two replicates.

lorophenol) and aromatic oil, T.C.A. (trichloroacetate), Carbide and Chemical Experimental Herbicide No. 2, and sodium P.C.P. The results obtained showed some control, but under the conditions in this test they did not justify their application. No detrimental effects to the cotton were apparent.

Postemergence chemical weed control was tried both by early application when the plant stalks were about 3/16 in in diameter and by late application after cultivation had ended. The materials used in the early trials were T.C.A., Shell Experimental Oil, Maleic Hydrazide, Carbide and Chemical Experimental Herbicide No. 2, Richfield Weed Oil, and a fortified oil emulsion consisting of Dow General Weed Killer, diesel oil and water. Fair to good weed kills were obtained with the oils applied at 20 gal per acre, but slight to no kills were obtained with the other materials. In applying the materials, care was taken to position and direct the sprays so that the foliage was not touched and only the base of the main stalk was sprayed. Plants were damaged slightly by two of the oils.

TABLE 5. COMPARISON OF PLANTING BY CONTINUOUS DRILLING AND HILL DROPPING

Year	1949			1950		
Type of planting	Hilldrop	Continuous		Hilldrop	Continuous	
Planting rate, pounds seed per acre	12.6	13.5	7.6	11.7	11.7	7.1
Plants per acre, thousands	48.6	48.9	28.1	36.0	35.4	21.6
Average plant spacing, in	14*	3.2	5.6	12*	4.4	8.1
Yield, bales per acre	2.60	2.75	2.60	2.49	2.74	2.44
Height of first fruiting node, in	6.2	6.3	4.8	5.9	6.4	5.2
Picker efficiency, per cent	96.3	96.2	95.6	93.8	92.2	93.1
Per cent trash	8.3	8.2	8.1	5.1	5.6	6.1

*Center to center of hills.

The materials used in the late trials were Richfield Weed Oil, No-Ho, Shell Experimental Oil, Endothol, and a fortified oil emulsion consisting of Dow General Weed Killer, diesel oil and water. The fortified oil emulsion was also tried with additives of T.C.A. and sodium P.C.P. There was very little difference in the results obtained with the different materials. From observations they seemed to kill the small weeds but had little effect on the large ones. The materials were applied with a special high-clearance spray unit having shields that prevented the materials from contacting the foliage. Though some damage to the plants was visible, the yield was not significantly reduced by any of the materials except the fortified oil containing sodium P.C.P., which reduced it about 10 per cent.

The results of the various tests with chemical weed control indicate that pre-emergence applications do not show much promise under the conditions at the Shafter Experiment Station but that postemergence applications of some materials may be practical. However, before they can be recommended for general use, more study is needed on their application and effectiveness, and also on their economic feasibility.

Flaming in combination with cultivation for weed control was tried in 1949 and 1950. Three tests were included in the 1949 trials with the initial flamings applied at different stages of the cotton's growth and with the flamings continued at one-week intervals thereafter. Two treatments were included in the 1950 tests with the initial flaming of one treatment 16 days later than the other. Additional flamings were applied at intervals of about three weeks. Weeds in the flamed plots were definitely reduced over those in the check, and there was no detrimental effect on the cotton as shown in Table 7. This method of weed control shows promise of becoming a common practice in California and will be tried by some growers in 1951.

Mechanical weed control was tried with various equipment such as rotary hoes, sweeps, and weeder wheels, and by heavy dirting and late cultivation. No outstanding results were obtained, but cultivation after the normal "lay-by-time" definitely helped to control late weeds. In 1950 an International M high-clearance picker-tractor was used for the late cultivation. The picker was removed and the drive was changed to make it operate forward in the normal gears. By proper shielding of the wheels and other parts (Fig. 3) that might damage the cotton, cultivation was possible for nearly a month after regular cultivation had ended, without reducing the yield. The use of this type of equipment for controlling late weeds has considerable promise.

Defoliation. Defoliation before harvesting is very desirable to reduce trash and leaf stain and increase the grade of mechanically picked cotton. In 1950 tests using 3 dust and 18 liquid defoliants applied both by ground equipment and airplanes were conducted at the Shafter Experiment Station and on selected farms. The results were erratic, and none of the materials did a satisfactory job in all cases. More information is needed on the time of applying defoliants and the condition of the plant for best results.

TABLE 6. RESULTS OF THINNING TESTS WITH DIFFERENT MAKES OF MECHANICAL CHOPPERS

Method of thinning	Hand-thinned	Dixie	Mayco	B & P chopper	B & P weeder*	Eversman	Winter Weiss
Plants per acre, thousands	23.6	30.8	45.7	29.1	45.1	19.2	37.1
Average plants per hill	1.2	2.1	2.6	1.9	2.3	1.8	2.3
Gaps under 8 in, per cent	91	80	86	78	92	59	86
Gaps under 12 in, per cent	100	92	95	87	99	77	92
Yield, bales per acre	2.84	2.72	2.92	2.78	2.92	2.63	2.86

*Went over plots three times.

Harvesting. The number of mechanical pickers in California has increased rapidly in the past five years as shown in Fig. 1. In 1950 there were approximately 1450 pickers used in harvesting about one-third of the crop. In 1951 it is estimated that there will be at least 3,000 pickers in operation, but because of the increase in acreage they probably will pick less than half the cotton. These figures indicate that mechanical picking is being generally accepted in California and in time

TABLE 7. EFFECT OF FLAME WEED CONTROL ON YIELD, PICKER EFFICIENCY, AND HEIGHT OF FIRST FRUITING NODE

Year	1949				1950		
Date of initial flaming	6/17	6/24	7/1	——	7/8	7/24	——
Number of flamings	9	8	7	None	3	3	None
Yield, bales per acre	2.21	2.22	2.00	2.11	2.56	2.57	2.63
Picker efficiency, per cent	96.0	——	——	97.3	95.6	94.7	95.2
Height of first fruiting node, in	4.6	5.2	5.3	4.8	5.9	5.9	6.0

will be used to harvest nearly the entire crop.

Experience with pickers has been that the grade of the cotton is lower and the field loss higher than with hand picking. However, considerable progress has been made in improving this situation by special training and more experience of the operator, by following cultural practices that make machine picking more adaptable, and by the installation of more drying and cleaning equipment in the gins. As shown in Tables 3, 5 and 7, efficiencies of better than 95 per cent have ben attained with mechanical pickers. In 1950 at the Shafter Experiment Station out of 25 bales of first-picking cotton harvested early in October, 21 were classed as Middling and 4 as Strict Low Middling. First-picking cotton harvested a month later in the same field was all classed as Strict Low Middling. A study made in 1949 by T. R. Hedges of the Agricultural Experiment Station, University of California, and W. R. Bailey of the Bureau of Agricultural Economics, U.S. Department of Agriculture, showed that machine-picked cotton for the season averaged between Strict Low Middling and Low Middling, while hand-picked cotton averaged between Middling and Strict Low Middling. There was considerable variation in the grades between various sections of the growing area and also between different growers.

TABLE 8. COMPARISON OF COSTS OF MECHANICAL AND HAND HARVESTING OF COTTON IN CALIFORNIA

Year	Number of machines	Average bales per machine	Cost per bale: Operating & overhead	Grade loss	Field loss	Total cost	Hand-picking cost
1948*	23	244	$16.62	$ 7.37	$5.99	$29.98	$46.00
1949†	63	230	14.65	10.32	1.20	26.17	45.00
1949‡	16	190	25.50	2.56	4.47	32.63	45.00
1949‡	10	295	11.06	11.20	8.12	30.38	47.37

*Burlingame, Burt B. and Bailey, Warren R.: Cost of Harvesting Cotton with Mechanical Pickers, California, 1948. Mimeographed Report, Agricultural Extension Service, University of California in cooperation with U.S. Department of Agricultural Economics, January, 1950.

†Bailey, Warren R. and Hedges, Trimble R.: Economics of Mechanical Cotton Harvesting in the San Joaquin Valley, 1949. Mimeographed Report No. 111, Giannini Foundation of Agricultural Economics, Agricultural Experiment Station, University of California, January, 1951.

‡Cost studies by two different cotton growers on their own pickers.

Costs of machine picking have been significantly less than for hand picking even when the lower grades and field losses have been taken into account. In Table 8 are shown the results of cost studies made in 1948 and 1949 by two public agencies on a number of different farms and by two large growers on their own machines. All of the pickers in these studies were made by International Harvester Co. The variation in the costs of the different items making up the total may be attributed to the different assumptions made in calculating and also on the number of bales of cotton picked. For example, the depreciation assumed varied from a low of 10 per cent to a high of 25 per cent per year while the bales picked per machine varied from 190 to 295. The total costs were all in the neighborhood of $30 per bale, however, or about two-thirds the cost of hand picking.

The prospects for the complete mechanization of cotton growing in California are good, but there are still problems to be solved. The main problem at the present time is weed control. If a satisfactory method can be devised to eliminate hand hoeing it will not only cut out labor for that purpose but will also make possible the elimination of hand thinning. The cotton could either be planted to a stand or thinned with mechanical choppers. Defoliation is another problem that still has not been solved satisfactorily but on which progress is being made. While defoliation itself is not a labor problem, it is important in the use of mechanical pickers. Mechanical harvesting is being generally accepted, and although there is still improvement to be made in the pickers and their use, they are doing a reasonably satisfactory job.

Breeding and Adapting of Cotton

(Continued from page 488)

bolls, rather than the size, appears to be the important factor in the effective recovery of the crop by the spindle-type picker. Inner surfaces of the dry burs should be relatively smooth, burs should be straight and approximately equidistant from each other. These are inherent conditions that are often influenced by adverse environment.

Cotton breeders and growers should direct the harvest date to the period of most favorable weather in the light of seasonal averages of their particular area. By the universal use of Acala 4-42 the harvest season in the San Joaquin Valley of California has been favorably shifted by as much as 30 days in the extreme north portion.

Where machine picking is contemplated, insect control must be timely and effective to insure good distribution of the crop over the plants. With well-balanced crops several known varieties stand erect with up to four bales per acre, but if out of balance may lodge badly with much lighter yields. Lack of proper insect control is conducive to excess plant growth, severe lodging and other conditions which interfere with machine picking.

Evidence is lacking that defoliability is a varietal problem, although there are wide differences in the date at which this condition is attained. For dependable defoliation, fields should be evenly grown and all conditions, such as unlevel land and salinity, should be corrected before the crop is planted. Fertilizers should be judiciously used and nitrogen in particular should be fairly well depleted before maturity. The harvest should follow close behind abscission of the leaves.

Soil Survey Data

(Continued from page 485)

ten years ahead of the U.S. Department of Agriculture report. The so-called "Bureau" reports have not yet been published on survey areas on which the field work was completed in 1939.

The county assessor takes our report and transfers the soil map to *his* ownership maps and carefully measures the area of each soil separation for each ownership. In the case of large areas, with a single ownership of several thousand acres, he may even break the measurement down to units of a section.

In the assessors files is also a "farm classification record" sheet for each property owner. This sheet contains a record of size and cost of buildings and equipment; the number of cattle, sheep, and other livestock; acreage and value of crops, etc., and a land record. Under the heading of "land" he enters the natural land symbol, the area, and the Storie-Index rating for each soil type. This is followed by columns giving the assessed value per acre and the assessed value for the total of the soil type. These are then totaled for the assessed value of the land on the property. There are also columns on this sheet for notes on irrigation facilities, accessibility, frost hazards, etc.

Assessors claim that they are getting wonderful cooperation from the farmers and complaints about the inequality of rural assessments have almost vanished.

Some very interesting experiences have been noted when farmers have suddenly found their assessments raised because of the new approach to evaluation. Almost without exception it is the farmer owning first-class land, of high productive capacity, who has found his assessment raised. However, when he learns that all the lands in the county have been similarly treated, he usually admits that his land is really good and that he should pay a higher tax than a neighbor who has poorer land. Naturally, when assessments have been lowered, the assessor is not bothered by the owner asking why.

County boards are so anxious to get this detailed soil information that they are offering financial aid as a means of speeding up a soil survey in their county.

We are finding ourselves in the disquieting position of losing our experienced soil surveyors to the county in which they have been working. County officials realize that men who have worked on the county soil survey are best qualified to carry on interpretative soils work. Therefore, our experienced men are being offered positions by the state agricultural extension service and on the county assessor's staff.

Some New Data on Resistance of Grains to Air Flow

By Claude K. Shedd
LIFE FELLOW ASAE

APPARATUS used for the tests reported in this paper is shown in Fig. 1 and following is a description of it:

Air under pressure is supplied by means of an open-top cylindrical tank containing water and a cylindrical bell of smaller diameter than the tank and arranged to be moved up and down inside of the tank. The tank has 4-in outlet (and inlet) pipe for air, located vertically in the center of the tank and extending through the tank floor and up above water level.

This 4-in air pipe extends from the tank to a plenum chamber made from a 100-lb steel grease drum. On top of this drum is a cylindrical grain bin 8 in in diameter and 9 ft 2 in high. The floor of this bin, at the top of the plenum chamber, is supported on ¼-in rods about 2 in apart. The floor may be any desired kind of perforated metal or screen. The floor used in testing corn, oats, soybeans, and rice was sheet metal with perforations 1/16 in wide and ½ in long. The area of openings was 21.8 per cent of the floor area. For the tests of clover seed, ¼-in hardware cloth was placed on the supporting rods and this was covered with 30 x 30-mesh brass screen.

The operation of the apparatus is expained as follows, referring to Fig. 1. As the bell moves downward, air is forced upward through grain in the bin; as the bell moves upward, air is drawn downward through grain in the bin. As an alternative, there is an opening closed by a large rubber stopper in the horizontal section of the 4-in air pipe. By removing this stopper, air can be moved to or from the tank without passing through the grain.

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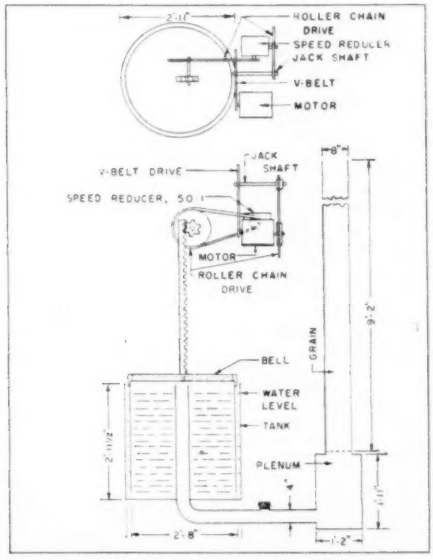

Fig. 1 Outline drawing of apparatus used in tests of resistance of grains to air flow

The mechanism for moving the bell up and down consists of a reversible electric motor, a V-belt drive from the motor to a jackshaft, a roller-chain drive from the jackshaft to a worm-gear speed reducer, a roller-chain drive from the speed reducer to a pinion and a rack attached to the bell. The motor is oversize for the load imposed by this apparatus. No change in speed of the jackshaft was observed in going from maximum to minimum load.

Since the driving mechanism from the jackshaft to the bell is all by chain, sprockets and gears, the exact speed of motion of the bell can be calculated when the jackshaft speed is known. The rate of air delivery is governed by the displacement of the bell under motion. The displacement can be calculated from the bell dimensions and its speed of motion. This calculation can be as accurate as the measurements of the bell dimensions and the jackshaft speed. To get the rate of flow of air through the grain, the air delivery is divided by the area of cross section; that is, the floor area of the bin. This gives a rate of flow in cubic feet per minute per square foot of floor. By changing sprockets in the roller-chain drives, different speeds of bell travel and therefore different rates of air delivery can be obtained. With a jackshaft speed of 238 rpm, the following rates of air delivery in cubic feet per minute per square foot of bin floor are available: 1.11, 2.23, 3.34, 4.46, 6.69, 10.03, 13.38, 20.07, 26.75, 30.10, 40.13 and 60.20. The jackshaft speed was measured by use of a stop watch and counting chain revolutions, then multiplying by the number of links in the chain and dividing by the number of teeth on the jackshaft sprocket. Nearly all measurements came within ± 0.5 rpm of 238, so a jackshaft speed of 238 rpm was used in calculations. The combined errors in calculated air delivery due to inaccuracies in measuring jackshaft speed and dimensions of the bell and the grain bin probably do not exceed ± 1 per cent.

The cylindrical grain bin, 8 in in diameter and 9 ft 2 in high, was made up in sections 18 in long. The ends of these sections were sawed and ground off square to make butt joints. This produced a smooth surface on the inside of the bin wall from top to bottom. The joints were held in place by a steel band ½ in wide soldered around the outside of the bottom of each bin section and fitting around the top of the section below. The joints of bin sections were sealed airtight by covering the joint with electrician's scotch tape, applying vacuum wax around the metal seam, then covering with a tight-fitting rubber band about 2 in wide and applying vacuum wax again at the metal seam. These rubber bands were cut from a 6.70-15 automobile tire tube.

The entire apparatus was tested for air tightness by covering the top of the bin, then applying air pressure. A slow drop was observed in air pressure, indicating slight air leakage. This may have been at the temporary cover applied to the top of the bin, but, in any event, it was no more than a fraction of 1 per cent of rates of air flow under pressures used in these tests and therefore it was disregarded.

Pressure measurements were made at the plenum chamber and at each foot above the bin floor. In most of the tests, the bin was filled to a depth of 9 ft. The plenum chamber pressures were taken from a copper tube passing around the plenum chamber and connected to four small holes in the plenum-chamber wall. The pressure at each foot level in the bin was taken from a short length of copper tubing connected to a single small hole in the bin wall.

Three water manometers were used to measure air pressures: a micromanometer to measure pressures less than 0.75 in, an inclined-tube manometer to measure pressures up to 4.4 in, and a vertical U-tube manometer to measure pressures up to a little more than 8 in, water gage. The micromanometer was read to 0.001 in; the inclined-tube manometer to 0.01 in, and the U-tube manometer to 0.1 in. The inclined-tube manometer was calibrated and adjusted by comparing

its readings with those of the other manometers at the same pressures.

There was some surging of pressure in most of the test runs but not enough to prevent accurate readings. Judging by the results of repeated measurements at the same pressures and by the smoothness of curves obtained by joining observation points plotted on graph paper, it is estimated that the combined probable errors (caused by pressure variations and by errors in measurements of pressures and rates of air flow) come within $\pm$ 0.003 in for pressures measured by micromanometer, $\pm$ 0.02 in for pressures measured by inclined-tube manometer, and $\pm$ 0.10 in for pressures measured by U-tube manometer.

RESULTS

Size of Bin. One of the first questions that may be raised is: "Can the results obtained in a miniature bin of this kind be applied without modification to ventilation of a full-size bin?" The effect of the wall surface on air flow was tested by filling the bin to a depth of one foot with a flat sheet of galvanized steel 7 in wide set vertically on a bin diameter. This increased the metal surface in contact with the grain by 55 per cent. Resistance to air flow was measured at three rates: 6.69, 20.07 and 26.75 cfm per sq ft. Then the flat sheet was pulled out vertically, being careful not to disturb the corn more than necessary. Resistance to air flow was measured again at the same rates as before. In the test at 26.75 cfm per sq ft, the resistance was the same with the extra wall surface in place as with it removed. In the other two tests the resistance pressure was slightly reduced when the extra sheet metal was removed. The fill of grain may have been loosened a little by removing the extra sheet metal. Other tests were made by use of an extra 4-in sheet metal pipe set in the grain. Results were similar.

These results do not show precisely the effect of the wall surface on air flow because the density of the grain may not have been the same in a pair of tests. It is apparent, though, that the effect of the wall surface on air flow is small. Another question in this connection is whether or not the grain will settle to the same density in this miniature bin as in a full-size bin. Density of grain in pounds per cubic foot was determined in tests of resistance to air flow, but it is not known what the density of the same grain would be in a full-size bin.

Air Forced or Drawn Through Grain. This apparatus provided a good means of comparing the effect of forcing vs. drawing the air through the grain since, with the same sprockets in use, the volume of air in cubic feet per minute per square foot is the same for the two directions of flow. Tests to answer this question showed that the minus static pressure when drawing air through the grain was slightly less than the positive static pressure when forcing the flow at the same rate in cubic feet per minute per square foot. For example, in a test of a flow of 30 cfm per sq ft through 4 ft of oats, the positive static when forcing was 4.31 in and the negative pressure when drawing was 4.24 in. Other tests showed differences in about the same proportion which, in this case, is 1.6 per cent less when drawing the air through the grain. If the comparison is made on a basis of flow in pounds instead of cubic feet of air, a different result is obtained. Barometric pressure was 29.60 in of mercury, equivalent to 402 in of water. Air was forced under pressure of 402 + 4.31 in and drawn under pressure of 402 − 4.24 in. If temperature differences are disregarded, the weight of air per cubic foot under suction would be 398/406 times the weight when forcing flow. This would be a reduction of about 2 per cent in weight of air. However, the actual weight of air delivered would also be affected by small temperature differences that would be complicated to estimate. It is pretty safe to assume that the apparent saving in power by drawing rather than forcing the air flow is offset by the reduction in weight of air delivered, and therefore there is no saving in power cost per pound of air delivered.

All of the pressures used in the graphs and the tables with this paper were measured when forcing air flow through the grain.

Air Flow and Pressure Data. Up to the present time, tests have been made of corn under several conditions of moisture and foreign material content, oats at three different moisture contents, rough rice at two different moisture contents and

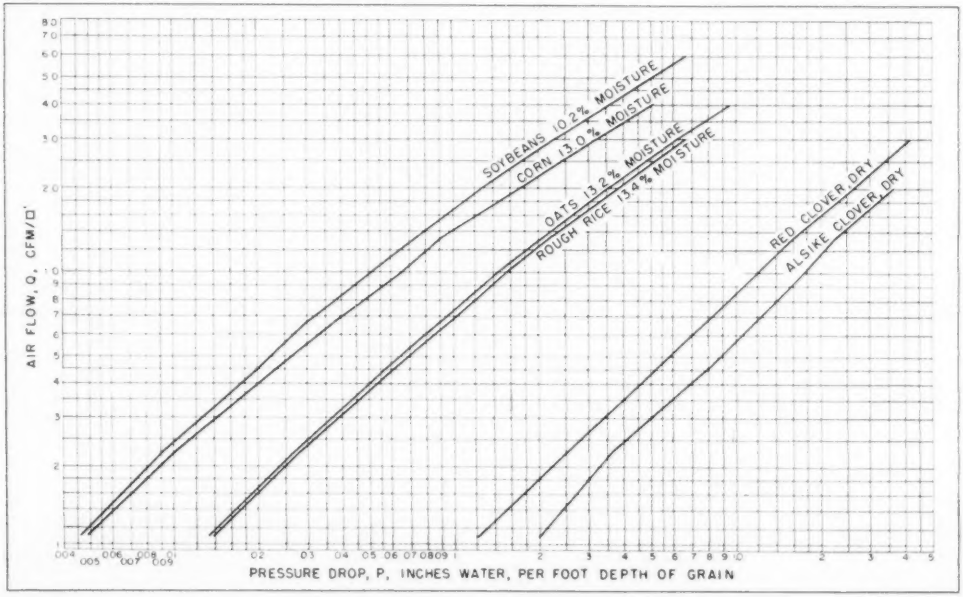
AIR FLOW, Q, CFM/D²
PRESSURE DROP, P, INCHES WATER, PER FOOT DEPTH OF GRAIN
SOYBEANS 10.2% MOISTURE
CORN 13.0% MOISTURE
OATS 13.2% MOISTURE
ROUGH RICE 13.4% MOISTURE
RED CLOVER DRY
ALSIKE CLOVER, DRY

Fig. 2 These graphs show air flow and pressure data obtained in tests of clean, loose-filled, dry soybeans, corn, oats, rough rice, red clover, and alsike clover

TABLE 1. AIR PRESSURES REQUIRED TO FORCE VARIOUS RATES OF AIR FLOW THROUGH LOOSE-FILLED, CLEAN, DRY GRAINS

1	2	3	4	5	6	7
Air flow, cfm/sq ft	Soybeans, lot 1, 10.2% moisture	Corn, lot 2, 13.0% moisture	Oats, lot 1, 13.2% moisture	Rough rice, lot 1, 13.4% moisture	Red clover seed, dry	Alsike clover seed, dry
	Pressure drop, inches of water, per foot depth of grain*					
1.11	.0046	.0049	.0132	.0138	.12	.20
2.23	.0091	.0102	.0268	.0279	.25	.36
4.46	.0195	.0228	.0558	.0592	.51	.78
6.69	.0296	.0374	.089	.096	.77	1.17
10.03	.0506	.0648	.144	.152	1.20	1.75
13.38	.0725	.090	.206	.219	1.60	2.25
20.07	.125	.170	.348	.378	2.6	3.6
30.10	.225	.316	.612	.65		
40.13	.350	.502	.94			
60.2	.66					

NOTE: For description of each lot of grain, see Table 2.

*For example, the pressure required to force air flow of 10.03 cfm per sq ft of section through 6 ft depth of loose-filled soybeans, is found as follows: The pressure drop per foot depth from the table is 0.0506 in; 6 x 0.0506 = 0.3 in, the required pressure.

clean, dry soybeans, red cover seed, and alsike clover seed. All grains were tested with the bin filled by two different methods which will be called loose fill and packed fill. The loose fill was made by pouring the grain into a funnel which was held with the outlet just above the surface of the grain in the bin. Care was used not to jar the bin. The packed fill was made by pouring the grain into place from 1 to 2 ft above the grain surface without use of the funnel and tapping the bin wall with a wooden mallet to settle the grain after each foot of depth was added. A record was kept of the weight of grain added for each foot increase in depth.

Fig. 2 shows graphs on log-log paper of air flow and pressure data obtained in tests of one lot each of clean, loose-filled, dry soybeans, corn, oats, rough rice, red clover and alsike clover. Table 1 records the same data that are shown graphically in Fig. 2.

Measurements of pressure were made at each foot of depth. It was found that resistance pressure increased in proportion to depth. There were small variations which may have been caused by variations in density of fill of grain. There was no consistent difference from bottom to top of bin in weight of grain per cubic foot, and theoretically there is no reason to expect a variation in resistance pressure per foot of depth as long as there is no air leakage at bin walls. For reasons just stated, the resistance pressures given in Table 1 and Fig. 2 are stated as pressure drop per foot depth of grain.

It will be noted that the tests included various rates of air flow from 1.1 to 40.1 cfm per sq ft of floor area. The lines joining observation points in Fig. 2 have considerable curvature and are convex upward. This is at variance with most of the previously reported data as will be seen by reference to *Agricultural Engineering Data 1* published by American Society of Agricultural Engineers in 1948, in which most of the graphs are straight lines on log-log paper. In most cases, the tests reported in this publication were made over a relatively narrow range of rates of flow, and no doubt the straight-line graphs fit the data fairly well. In Fig. 2, it may be observed that a straight line would fit the data with sufficient accuracy for rates of flow above 13.4 cfm per sq ft; but if this line were extrapolated to rates of flow under 10 cfm per sq ft, there would be large errors in estimates of the flow-pressure relationship.

Not all of the graphs in the publication referred to above are straight lines. For example, on page 6 there is a graph by S. M. Henderson for clean oats in which the flow-pressure lines are curves. In the original publication of his data on oats, Henderson commented on the curved characteristic of the flow-pressure lines.

Effects of Moisture, Foreign Material and Density. In Table 2 are recorded the description of grain in the different tests and the resistance pressure related to that shown in Table 1 and Fig. 2. Conditions as to packing and content of moisture and of foreign material caused more variation in air flow than had been expected. *(Continued on page 520)*

TABLE 2. RESISTANCE OF VARIOUS KINDS AND CONDITIONS OF GRAIN TO AIR FLOW IN RELATION TO DATA SHOWN IN TABLE 1 AND FIG. 2

Description of lot of grain	Pressure ratio*
SOYBEANS	
Lot 1. Lincoln variety. Foreign material, 0; splits, 1.0%; wt. of 500 seeds, 77.5 g; test wt., 58.5 lb/bu; moisture content, 10.2%	
Loose fill, 44.2 lb/cu ft (Table 1 and Fig. 2)	1.0
Packed fill, 49.9 lb/cu ft	1.42
CORN	
Lot 2. Cracked grain and foreign material, 2.6%; damaged kernels, 0.5%; test wt., 57.0 lb/bu; wt. of 500 kernels, 142 g; moisture content, 13.0%	
Loose fill, 46.9 lb/cu ft (Table 1 and Fig. 2)	1.0
Packed fill, 48.1 lb/cu ft	1.25
Lot 3. Cracked grain and foreign material, 0.5%; damaged kernels, 3.0%; test wt., 57.0 lb/bu; wt. of 500 kernels, 141 g; moisture content, 12.8%	
Loose fill, 45.0 lb/cu ft	0.89
Packed fill, 47.4 lb/cu ft	1.25
Lot 3a. Same as lot 3, except wet to 20.0% moisture content	
Loose fill, 43.2 lb/cu ft	0.56
Packed fill, 44.2 lb/cu ft	0.67
Lot 3b. Same corn as lot 3a, but dried to 13.9% moisture content	
Loose fill, 44.5 lb per cu ft	0.82
Packed fill, 46.9 lb per cu ft	1.14
Lot 3c. Same as lot 3, except 2.0% cracked grain and foreign material added and moisture content 13.0%. Loose fill	
Lot 3d. Same as lot 3, except 5.0% cracked grain and foreign material added. Moisture content, 12.8%	
Loose fill, 45.3 lb per cu ft	1.32
Packed fill, 47.8 lb per cu ft	2.12
OATS	
Lot 1. Foreign material, 0.1%; damaged kernels, none; test weight, 39 lb per bu; wt. of 500 kernels, 13 g; moisture content, 13.2%	
Loose fill, 33.1 lb per cu ft (Table 1 and Fig. 2)	1.00
Packed fill, 35.8 lb per cu ft	1.55
Lot 1a. Same grain as lot 1 but at 8.4% moisture content	
Loose fill, 33.0 lb per cu ft	1.04
Packed fill, 36.1 lb per cu ft	1.51
Lot 1b. Same grain as lot 1 but at 19.2% moisture content	
Loose fill, 31.9 lb per cu ft	0.92
Packed fill, 34.8 lb per cu ft	1.38
ROUGH RICE	
Lot 1. Foreign material, none; hulled whole kernels (head rice), 2.6%; hulled cracked kernels (brewer's rice), 1.6%; whole kernels with hulls on (rough rice), 95.8%; 500 whole kernels with hulls on weigh 12.0 g; moisture content, 13.4%	
Loose fill, 38.1 lb per cu ft (Table 1 and Fig. 2)	1.0
Packed fill, 40.6 lb per cu ft	1.33
Lot 1a. Same grain as lot 1 but at 20.7% moisture content	
Loose fill, 38.6 lb per cu ft	0.76
Packed fill, 41.3 lb per cu ft	1.16
RED CLOVER SEED	
Lot 1. No foreign material, no damaged seed, dry (moisture not tested); wt. of 500 seeds, 1.0 g	
Loose fill, 50.1 lb per cu ft (Table 1 and Fig. 2)	1.0
Packed fill, 52.2 lb per cu ft	1.5
ALSIKE CLOVER SEED	
Lot 1. No foreign material, no damaged seed, dry (moisture not tested); wt. of 500 seeds, 0.4 g	
Loose fill, 50.25 lb per cu ft (Table 1 and Fig. 2)	1.0
Packed fill, 53.4 lb per cu ft	1.3

*To find the pressure drop per foot depth of grain, multiply this ratio times the pressure given for the same kind of grain and the same rate of air flow in Table 1 or in Fig. 2.

Some Engineering Aspects of Electric Traps for Insects

By J. G. Taylor, H. O. Deay and M. T. Orem
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RESEARCH work on the control of corn borer moths by electric lamps and traps at the Indiana Agricultural Experiment Station in 1950 was quite extensive with over 50 trap installations made at 5 different locations. Although the corn borer flight was comparatively light during the summer in Indiana, principally because of a cold, wet spring, the 360 BL lamps appeared as effective as they had in the past*.

Grid Characteristics. Grids were operated at peak voltages ranging from 1,800 to 12,000 v with short circuit currents from 19 to 5 mamp with grid spacing varying from ⅜ to ⅝ in center to center.

The majority of the traps used in previous years had ⅜-in grid spacing with impressed voltages of 3,500 to 4,500 v. As these had proven unsatisfactory due to clogging of the grids, higher voltages with wider grid spacing were tested this year.

The peak voltage that may be impressed upon a ½-in grid (⅜ in spacing between grid wires) without "spillover" is in the region of 6,000 v. It was observed, however, that this arc-over occurred principally at the ends of the grid wires where the arcing was between the point sources. By bending the ends of adjoining grid wires 90 deg horizontally in opposite directions, the impressed voltage on the grids could be approximately doubled to 12,000 v without appreciable arcing.

With increased voltages on the grid a new trouble developed, that of leakage through the supporting insulators. The insulators had been designed for lower voltages and provided a continuous source of trouble. The physical shape of the insulators used was poor because it formed a pocket for the falling insects which soon provided a low-resistance path across the grids, thus reducing their effectiveness. An ideal insulator for insect traps might have the following characteristics:

(a) Hi-dielectric strength under all summer weather conditions;

(b) Long leakage path of such shape that it will not collect insects;

(c) High resistance to heat if subjected to electrical arcing;

(d) Good mechanical strength;

(e) Easy to work and manufacture; and

(f) Low cost.

One manufacturer of electric traps has used a lucite-type block that apparently meets most of these requirements except that it has little resistance to heat. However, the insulator was so mounted that it was not readily subjected to arcing from the grids.

An experimental trap was designed at Purdue using lucite rods as insulators; further development of such a design would apparently meet most requirements except that a slightly more elaborate trap frame would be required.

The use of 7,000 to 12,000-v transformers on a ½-in spaced grid eliminated most of the clogging on the larger, 1,270 sq in grids. However, the use of voltages of 12,000 v on a 209 sq in grid did not prevent clogging. It was further observed that the best killing effect was produced by using three 36-in grids (3,710 sq in), spaced ½-in center to center, and connected in parallel to a single 6,000-v transformer with short circuit current limited to 12 ma. Many insects hitting the grids on these traps seemed to fairly "explode". They did not cling to the grids and slowly burn as insects did on other traps with smaller grid areas with equivalent or higher voltages.

Apparently the reason for this increased killing effect is due to the electrical capacitance in the grids. Obviously with opposite grid wires connected to opposite sides of the alternating source each pair of grid wires will act as a capacitor with an air dielectric which will be in parallel with the capacitor formed by the next grid wire and so on.

As capacitors add in parallel, that is, $C_T = C_1 + C_2 + C_3 + C_4 + \ldots$, the total capacitance of the trap will be the sum of all the individual capacitances formed by adjoining grid wires. Likewise the capacitance of three traps of equal area would be three times the capacitance of a single trap.

As the grids have a 60-cycle alternating wave impressed across them, they charge alternately positively and negatively. When an insect strikes the open charged grid, it provides a relatively low-resistance path through which the stored energy of the capacitor is dissipated.

The energy in a capacitor is given by the relation $W = ½ C (E)^2$, where the energy W is in watt-seconds, C is the capacitance of the condensor in farads, and E is the peak voltage across the condensor.

Thus for a constant impressed voltage the energy available is directly proportional to the capacitance of the condensor which is formed by the grid wires.

Since $C = k K (A \div d)$ (for parallel plates), where k is a constant, K is the dielectric constant (in this case, air, which approximately equals unity), A is the effective area of the charged wires and d is the effective distance between the wires, the capacitance of a trap is directly proportional to its grid area.

By substitution $W = K^1 (A/d) E^2$, where K^1 is a constant consisting of $½ k K$.

The energy available at a grid due to its capacitance is therefore directly proportional to the effective grid area. Thus with equal voltage and grid spacing a 13 x 16-in grid would only have 208 ÷ 3710, or 5.6 per cent of the capacitive energy that would be available from the three 36-in square grids.

The effectiveness of the grids may thus be increased with a given transformer by (a) moving the grid wires closer together, (b) using larger grid areas, or (c) adding a capacitor in parallel with the grids across the transformer.

Moving the grid wires closer than ¼ in will reduce the maximum voltage that may be impressed to less than 5,000 v and will have a greater tendency to clog due to the killing of smaller insects, many of which would otherwise pass through unharmed.

The larger the grid area, the easier it will be for insects to strike the grid making it more effective. However, there is an obvious limit to grid area due to cost and physical dimensions.

The effectiveness of adding capacitors across the output of the grid transformer is being studied. It may be possible to install a small high-voltage capacitor inside the transformer case at small additional cost, that will greatly increase the killing effectiveness of the grids.

Obviously if the grid is more effective in killing insects, it must also be less safe to humans. The relative safety of such improvements must be thoroughly investigated before definite recommendations can be made.

The ½-in (c to c) spaced grid with a ⅜-in opening appeared from observation to be most satisfactory. Closer grid spacing tended to clog more rapidly due to smaller insects, while ½-in or larger grid openings apparently allowed some corn borer moths to pass through unharmed unless operated at potentials above 7,000 v. *(Continued on page 498)*

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1950, as a contribution of the Rural Electric Division. Authorized for publication as Journal Paper No. 564 of the Purdue University Agricultural Experiment Station.

The authors: J. G. TAYLOR and M. T. OREM, respectively, agricultural engineer and agent (agricultural engineer), division of farm electrification, U.S. Department of Agriculture; H. O. DEAY, professor of entomology, Purdue University.

*TAYLOR, J. G. and DEAY, H. O.: Use of Electric Lamps and Traps in Corn Borer Control. AGRICULTURAL ENGINEERING, vol. 31, pp. 503-505, 532 (October, 1950).

Effect of Herbicides on Rubber-Covered Cable

By J. W. Martin, C. I. Seely and W. H. Knight
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PREVENTING plant growth from obscuring lights or reducing their effectiveness in the airport lighting system is a problem common on many airports which have installed field lighting equipment. Mowing is laborious and expensive, and clipping is sometimes delayed or not done at all. Control of vegetation around and between the lights by soil sterilization appears to be more desirable than mowing, if the chemicals used do not damage the lighting cable and fixtures. The use of herbicides for airport weed control has received little attention.

The Idaho Agricultural Experiment Station undertook to find if weed-spray chemicals would affect the insulation of the lighting cables when applied in amounts necessary for soil sterilization. Cable with rubber insulation and neoprene sheath is the type the Airports Division of the CAA recommends. At present, and for some time past, cables used for airport lighting have conformed to CAA Specification L-824.

The project was divided into two phases. The first phase was set up June 25, 1949, and consisted of 12 jars, each containing a different herbicide and a 16-in length of the standard airport cable. In addition to the 16-in piece of cable, short pieces of the rubber insulating material were dropped into the jar. The purpose of the short pieces of insulating material was to note any deteriorating effect or swelling of the rubber caused by submergence in the solution. Each jar was sealed by using an ordinary jar cap covered with paraffin wax. Table 1 lists the herbicides and the concentration used in each jar. The test samples were placed in a 70 F room to keep them from freezing and observed once each week for 336 days.

The second phase of the project consisted of a laboratory testing procedure that duplicated as nearly as possible actual field conditions. Twelve wooden boxes 18 x 36 x 30 in high were built to hold approximately ½ ton of soil. Each box was lined with an 18-in strip of copper screen to serve as a ground connection for checking the electrical resistance of the insulation. Four lengths of the single-conductor cable were placed in each box at levels of 6, 12, 18 and 24 in. One end of the cable was cleaned of insulation to allow connection to the bridge-meg. The other end of the cable was covered with electrician's rubber tape. The instructions as given on page 6 of the CAA specification No. L-108 were followed as to backfilling when the dirt was placed around the cables.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and is a contribution from the Idaho Agricultural Experiment Station, published with approval of the director as Research Paper No. 320.

The authors: J. W. MARTIN, C. I. SEELY and W. H. KNIGHT, respectively, agricultural engineer, agronomist, and farm electrification project director, Idaho Agricultural Experiment Station, Moscow.

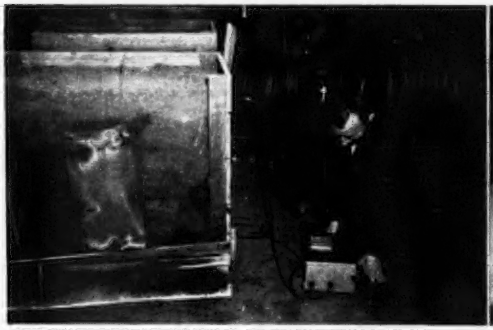
The earth used was a silt loam with 10 per cent sand added to make certain that the herbicides would be carried to the level of the cables or below. The project was started on June 20, 1949, when the boxes were filled with soil. Before the chemicals were added to the box the resistance to ground was measured by the use of a bridge-meg electrical-resistance tester. The instrument measures resistance from 1/100 ohm to 100 megohms when a voltage of 600 v is impressed on the line by a hand magneto. In each case the resistance to ground was in excess of 100 megohms and the instrument registered infinite resistance.

The herbicide chemicals were applied to the surface of each box in the amounts shown in Table 2. The rates of application used were purposely higher than normally used or required for complete soil sterilization.

Four gallons of water were added to each box for the purpose of carrying the chemicals below the surface of the ground and distributing them through the soil. Water was added at regular intervals throughout the summer and fall of 1949 and again during the spring of 1950 in an attempt to keep the moisture level of the soil to about field capacity. Readings with the bridge-meg were made once each week during the 341-day test period.

TABLE 1. TESTS ON CABLE SECTIONS SEALED IN GLASS JARS
(Jars sealed June 25, 1949; opened May 31, 1950)

Sample No.	*Material*	*Concentration*
1	Sodium chlorate	1 lb per gal water
2	Borax (sodium tetraborate)	Saturated solution
3	Sodium arsenite	Saturated solution
4	Calcium chloride	Saturated solution
5	Sodium chloride	Saturated solution
6	2,4-D (amine salt) (triethylamine 2,4-dichlorophenoxyacetate)	14 g per gal
7	STCA (sodium trichloroacetate)	⅓ lb per gal
8	Sodium chlorate and borax	½ lb $NaClO_3$ per gallon and saturated solution borax
9	Calcium chloride Sodium chloride	4 lb $CaCl_2$, saturated solution NaCl
10	2,4-D and STCA	7 g per gal 2,4-D and ⅛ lb per gal STCA
11	Sodium arsenite and sodium chlorate	Saturated solution sodium arsenite and ½ lb per gal sodium chlorate
12	Tap water	Used as a check



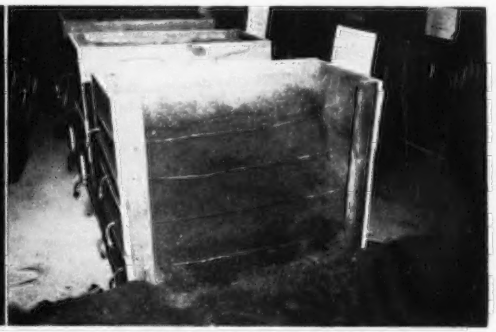


Fig. 1 *(Left)* Side view of a test box showing the strip of copper screen used as a ground and the bridge-meg used to test the resistance of the insulation • Fig. 2 *(Right)* Side view of a test box showing the exposed wires

TABLE 3. GENERAL CHARACTERISTICS OF HERBICIDES

Material	Relative period of sterility	Hazards	Major factors determining effectiveness	Relative initial costs	Remarks
Sodium chlorate	Medium	Fire and poison	Soil type and rainfall	High	
Borax	Medium	None	Soil type, rainfall and plant species	High	
Sodium arsenite	Long	Poison	Soil type, and plant species	Medium	
Calcium chloride	Medium	None	Rainfall, soil type and plant species	Very high	Dust control also frequently obtained
Sodium chloride	Long	None	Soil type and rainfall	High	
Chlorax	Medium	Small fire hazard	Soil type, rainfall and species	High	Generally better than either sodium chlorate or borax alone
2,4-D	Short	None	Rainfall, temp., low soil type and plant species	Low	Generally not used as a sterilant too selective. Could be used for broad-leaved plants
STCA	Short	None	Rainfall, temp., soil type and plant species	High	Generally not used except for perennial grasses

Figs. 1 and 2 show the laboratory setup used in the second phase of this project. Fig. 1 shows the copper screen in place and the bridge-meg as it was used to test the resistance to ground. Fig. 2 shows how the four sections of test cable were placed in each box.

TABLE 2. LABORATORY TESTS ON CABLES EMBEDDED IN SOIL

(Experiment started June 20, 1949, and terminated May 31, 1950)

Sample No	Material	Rate of application per square rod
1	Sodium chlorate	8 lb
2	Borax (sodium tetraborate)	30 lb
3	Sodium arsenite	10 lb
4	Calcium chloride	60 lb
5	Sodium chloride	255 lb
6	2,4-D (triethylamine 2,4-dichloro-phenoxyacetate)	¼ lb
7	STCA (sodium trichloroacetate)	2 lb
8	Chlorax (sodium chlorate 75% — sodium tetraborate 25%)	10 lb
9	Calcium chloride and sodium chloride	30 & 127 lb
10	2,4-D and STCA	⅛ & 1 lb
11	Sodium arsenite and sodium chlorate	5 & 4 lb
12	Water	Tap water used as a check

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1 The project was planned to test chemicals that could be expected to provide complete soil sterilization as far as possible or practical in the field, including those that either have been or might be used for soil sterilization work, and, hence, might offer possibilities as soil sterilants for airports.

2 The cable tested conformed to CAA specifications L-824 and was a rubber insulation with neoprene sheath composed of 50 per cent polychloroprene, antioxidants, accelerators, plasticizers, and fillers. As a sheath material, neoprene provides excellent resistance to oils, acids, alkalies, solvents, heat and flame.

3 Careful calculations were made as to the water-holding capacity of the soil and only enough water added so no chemicals would be lost by excess water draining from the box. Water was added to replace that lost by evaporation.

4 Based upon the results of the two phases of this test, no possible damage could occur to the rubber insulation from the use of these herbicides to control weed growth on an airport.

5 In phase I both the sodium arsenite and the 2,4-D seemed to give slight roughening of the surface. This could not be considered serious.

6 In phase II, 2-4-D appeared to cause slight roughness of surface. This could not be considered serious.

7 It is realized the volume change and appearance do not give a final answer to the problem. There may be cases where other tests will be necessary. However, it is felt that this series of tests shows very little chance for damage to the cable from the use of the herbicides included in this test.

8 The results of these tests indicate that any of the materials might be used for weed control on airports as far as effects on the rubber insulation of the cable is concerned, and hence the choice of a soil sterilant would be dictated by other local factors such as soil type, plant species present, rainfall, initial and final costs, fire hazard, poison hazard, and the period and completeness of sterility desired.

Some of the general characteristics of the major materials tested that would influence a choice of material are shown in Table 3.

Electric Traps for Insects

(Continued from page 496)

Lamps. A rather elaborate field test was made in sweet corn to determine the number of 360-BL lamps that are required per trap. Tests were made with one, two, and four lamps per trap of both 15 and 30-w sizes.

Results of eight counts made of population around each trap, just before the corn was snapped, indicated that a total wattage of 60-w per trap was the most attractive. Sixty watts of 360-BL lamps mounted horizontally resulted in a 70.4 per cent reduction of population over an unlighted check in the same field in a count made around the traps 15 rows out, compared to reductions of 42.2 per cent with 15-w and 31.0 per cent with 120-w of similar type lamps. There was some indications that lamps of higher wattage gave better results further away from the traps; however, the traps in our test were too close together to permit an accurate comparison.

Similar lamps mounted vertically did not reduce the population as well around the traps as lamps mounted horizontally, although vertical lamps of equal wattage radiate more energy in a horizontal plane.

Observations of Second Generation Flight. A late-planted field of dent corn was selected to study the use of traps for second generation moths.

Moths of the second generation did not appear to be attracted directly into the traps as well as first generation moths. They appeared to fly above the corn to within a few feet of the trap then duck down into the corn without hitting the grid. It was also noticed that, when the night was still, the moths would fly above the corn tops, but when a breeze was blowing they would fly below the tops of the corn. Late in the season secondary traps were placed directly below the main traps which were just above the corn.

Although these secondary traps were only in operation a few days while the moths were still flying they appeared to make good catches. In one application a single 15-w "black light" mounted on an 18-in square grid below three 100-w CH-4 lamps killed large numbers of moths.

Other Trap Designs. A revolving-type trap was designed and tested at Purdue. This trap had a stationary light source at its center around which revolved a cylinder of tightly stretched piano wires. The wires were not energized but killed the insects by contact. The cylinder was driven by a small electric motor and rotated at a speed of 450 rpm. Few insects that came into the trap escaped; however, some difficulty was encountered by small weak-flying insects that could not come in against the air currents created by the revolving trap.

Study on Septic Tanks and Septic Tank Disposal Systems

By T. W. Bendixen and S. R. Weibel

STUDIES on household sewage disposal systems are being conducted at Cincinnati by the U.S. Public Health Service as a cooperative project under the programs of the Housing and Home Finance Agency and the Public Health Service. That such studies are needed is evident from the lack of basic facts on the behavior of the various parts of these small systems.

The Joint Committee on Rural Sanitation, which consists of representatives of official municipal, state, and federal agencies, has developed a set of uniform recommendations on individual sewage-disposal systems, which are set forth in Reprint No. 2461 from the Public Health Reports, entitled "Individual Sewage Disposal Systems, Recommendations of Joint Committee on Rural Sanitation." It is proposed that as definite conclusions are reached in the research studies under way at Cincinnati, this publication will be revised to include results applicable to systems serving suburban and rural homes.

As a guide to the size of this field, it has been estimated (1)* that some 17 million persons in this country are dependent on septic tank-soil absorption systems, as compared with about 22 million persons being served by all other types of complete sewage treatment in municipal practice. Present trends toward living in suburban areas and the modernization of farm homes are making the place of these systems increasingly prominent.

A poll of local health departments over the country concerning local practice in this field has pointed out many problems for study. Aside from the technical aspects of design and installation of systems, the maintenance and care of the systems present additional problems. Individual household sewage-disposal is a peculiar field of sewage treatment in that the servicing of the system is up to the householder. Unfortunately he is not technically equipped for this function and, in many cases, he is totally unaware of any responsibility on his part to maintain and service the system in order to avoid trouble. We are told by septic tank cleaners, for instance, that in over half the cases in which cleaners are called in, the owner has not acted in time, the tank has gone beyond its capacity to store solids, and solids have been carried over and filled the soil absorption field. While it is possible to renew the usefulness of the tank by cleaning, the soil absorption field is another story.

We bring this up because we feel that solving the many strictly technical problems of treatment and disposal is not the complete solution. Along with it must come the means whereby the facilities will receive the attention necessary for proper operation. We know from experience, in the areas in which we have conducted examinations of residential systems, that in many cases the householders seemed to be much interested in their sewage facilities, but did not know what facilities they had, where they were, nor that attention was required. A little advice to householders, and education on servicing responsibilities, will cut down considerably on the number of headaches in this field.

As to the technical side of the story, our studies are separated into two parts — the septic tank proper and the soil absorption fields.

This is an abstract of a paper presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Farm Structures Division.

EDITOR'S NOTE: Wide general interest suggests early publication of this paper in abstract form as a progress report on continuing research. For more detailed information on the procedures and preliminary results of this research, readers are referred to the authors.

The authors: T. W. BENDIXEN, soil scientist, and S. R. WEIBEL, sanitary engineer, U.S. Public Health Service (Environmental Health Center, Cincinnati, Ohio).

*Numbers in parentheses refer to the appended references.

SEPTIC TANK STUDIES

A total of 300 single-household-type septic-tank systems were examined in nine areas of the country. Such examinations were of primary interest for the establishment of rates of scum and sludge accumulations in operating systems. It appears that scum and sludge tend to accumulate volumetrically in the septic tank at a higher rate per person per year during the earlier years of service than after some six years of operation; after that it appears to increase at a more or less constant rate.

The smaller tanks tended to accumulate smaller volumes of scum and sludge, and the larger tanks larger volumes, than the average. This trend would indicate that the larger tanks are more efficient in settling.

Concerning structural tank materials, it appears that corrosion is most severe, inside the tank, at and above the water line. In general, precast concrete, tile, and brick stood up well for 20 years or more; poured-in-place concrete, for at least 10 years (no data for older tanks); steel tanks, a 7-year useful life on the average, running as high as 12 years in individual cases in the groups of tanks examined. Wood baffles were found sound in tanks up to 7 years old (no data for older installations).

In the laboratory studies, one of the first questions to be answered is the effect of tank shape and tank capacity on settling efficiency. For the same capacity, variation in shape appeared to affect efficiency very little.

The variation in liquid depths among these tanks was too small to be indicative of behavior under any radical departure from 4 ft, which is the depth recommended by the Joint Committee on Rural Sanitation (2). Study of the depth factor is now under way.

Either a larger capacity or some sort of compartmentation appears to improve efficiencies. Our conclusions are that variation in shape of single-compartment tanks, within reasonable limits, does no affect efficiency if capacity is adequate; that some sort of compartmentation appears desirable, and that, while no unqualified conclusion on capacity can be drawn from the study thus far, we believe that tanks of at least 500-gal capacity should be provided, to insure reasonably long periods of trouble-free service, and to prevent frequent and progressive damage to the absorption system due to sludge discharge.

Several exploratory trials of tank inlet, outlet, and intercompartment flow appurtenances have been made. Other outlet experiments are under way, in connection with the depth studies, in which the behavior of tanks with respect to depth, and also with respect to the distance between top of the accumulating sludge and the bottom of the outlet, is being observed. These are not far enough along to report at this time.

The matter of intervals between cleaning, or the point at which a tank should be cleaned, is pertinent. The detailed study of this will be presented at a later date.

Exploratory studies have also been made on the behavior of systems under various circumstances, namely, (a) the addition of ground garbage, (b) the addition of household detergents rather than soaps to the system, and (c) the addition of proprietary compounds purported to "condition" or to "clean" tanks.

Until further information is available the 50 per cent increase in tank capacity recommended by the Joint Committee (2) where garbage loadings are anticipated, appears to be a reasonable amount.

The behavior of tanks receiving wastes from households using detergents for laundering and dishwashing is a subject of current interest. There have been system failures, or failures earlier than usual, attributed to automatic-sequence washers.

The application of proprietary compounds purported to "condition" tanks, and even to "clean" tanks, is a point on

which we receive inquiries rather frequently. In our estimation, a reasonably well-designed tank needs no such props and, if inadvertent discharge of interfering materials has upset tank action, the simplest and safest remedy for the protection of the all-important soil absorption system is to pump out the tank and start over.

SOIL ABSORPTION STUDIES

The second part of the disposal system, the soil absorption field, is in some ways more important than the tank itself. The success or failure of the entire system is generally judged by the efficiency of the disposal field, and regardless of how good a tank may be, if the absorption field does not operate properly, the system can be a failure. However, we do not intend to minimize the necessity for a good tank; we should strive for the best over-all system possible, which includes both a good tank and a good absorption field.

The tremendous amounts of wastes that the soil of a typical absorption field is expected to absorb, as compared to the amounts of water it must absorb normally from rainfall or even from irrigation, should be pointed out. The average rainfall of the country varies from 30 to 50 in per year, with extremes ranging from 6 to 150 in per year. After allowing for stream runoff, evaporation, etc., of part of the rainfall, the soil is required to absorb the remaining amount, which is in the neighborhood of 20 to 40 in with a maximum of possibly 100 in per year. Under irrigation the maximum amount of water applied annually is also in the neighborhood of 100 in. As compared to these figures, the amount of effluent applied to a disposal field based on current design practice ranges from 200 in annually in the tighter soils to 1100 in annually in the more porous soils. In extreme cases encountered in the field, amounts of over 2,000 in were being applied. This comparison indicates that our problem is a major one from this viewpoint alone, without the complicating influence of soil-clogging factors which we know exist under sewage of effluent-dosing conditions.

The general problem, as far as the disposal system is concerned, is to determine the amount of soil absorption area to provide for any specific system. The answer to this problem depends in turn on a number of factors, such as the clogging characteristics of the effluents, the volume of effluents to be disposed of, the climate of the area, and, most important, the water-absorption characteristics of the specific soil being considered.

In the sewage-disposal field the work done by Henry Ryon (4) in the 1920's, and reported by Frederick (5) in 1949, has provided a useful tool for estimating soil-moisture absorption rates and needed absorption areas. Ryon proposed the percolation test, which has since become very widely used, by which he measured the rate that a soil would absorb clear water. He also developed an empirical relationship between this clear water rate and the rate that the soil could be expected to absorb sewage or septic-tank effluent successfully. It is this test and empirical relationship, or slight modifications thereof, upon which most of the soil-absorption field specifications of the various control agencies are now apparently patterned.

However, despite the usefulness and the widespread utilization of the Ryon test, there is considerable room for its improvement. We have proposed a number of modifications for improvement of the test. These modified tests have been studied and compared to a Ryon-type test on a variety of soils. In brief, these modifications are: (1) the substitution of a small bored hole for the dug hole, (2) the more complete saturation of the soil, and (3) the use of the minimum observed rate instead of the average, or some initial, rate.

We have not yet been able to develop any new empirical relationships, which will entail a tremendous field study, but we are doing the next best thing — investigating some of the individual factors which may affect the relationship. One of the first and basic things we want to know is what are the specific characteristics of septic-tank effluent which may affect the relationship by causing soil clogging. Logically we may consider the causes of soil clogging in three categories: (a) physical clogging, (b) biological clogging, and (c) chemical clogging. Septic tank effluent is a complicated physical, biological, and chemical system, and may contribute towards all types of clogging.

The physical type of clogging is obvious. It may result from the physical plugging of the soil pores by the solid particles in the effluent. Biological clogging, which is a common problem in agricultural water-spreading work (6), may result from the plugging of pores by biological bodies and by-products, or it may result from the biological activity destroying the soil structure. Actually, from preliminary studies, it appears that biological activity does not cause soil clogging under effluent-dosing conditions, but rather tends to reduce clogging that might be caused by other factors. Apparently a digestion of soil material takes place in the soil under normal effluent conditions, that results in a net decrease in the clogging effect of the effluent.

Chemical clogging is a common agricultural soils problem in the western part of our country, particularly under irrigation conditions. It is generally considered that waters, in which 50 per cent or more of the cations sodium, calcium, magnesium, and potassium, are sodium, are potentially harmful to the water absorption characteristics of the soil (7, 8). Even on sandy soils waters of 85 per cent sodium (percentage of dissolved minerals) or higher are likely to make soils impermeable after prolonged use. There are some indications that potassium may have similar effects.

The chemical quality of effluent will tend to vary with the water supply, so that the sodium problem may depend on the quality of water used. However, Wilcox (9) has reported that there is a tendency for salt concentrations of sewage-treatment-plant effluents (primarily from Imhoff tanks) to be at least twofold greater than those of the water supply, and, further, that the concentration of sodium in many of the effluents was disproportionately high. From this it appears that the possibility of effluents causing sodium clogging may be a problem for general consideration.

Another possible source of chemical-type soil clogging, which has come to our attention through inquiries, is through the use of some of the chemical septic-tank-cleaning compounds. Advertisements indicate that some of those cleaners contain sodium hydroxide. Two brands of such cleaners, upon chemical analysis, calculated as sodium hydroxide, contained the equivalent of about 95 per cent sodium hydroxide. Other cleaning compounds may contain potassium hydroxide.

As far as the soils are concerned, there is definite evidence that septic tanks receiving ground garbage may require larger absorption fields. Dosing of sewage-garbage effluent to soil cores caused a more rapid rate of clogging than did the sewage-only effluent, both on a basis of equal length of time of dosing and on a basis of an equal amount of suspended solids added. Based on the laboratory data, the additional area which would have been required for the cores receiving sewage-garbage effluent to absorb equal volumes of effluent in the same time as the cores dosed with sewage-only effluent would be roughly 20 to 35 per cent. If I were building a system for myself today, I would be inclined to increase its size by 50 per cent to provide for the inclusion of ground garbage waste.

Another factor which may affect the percolation rate-allowable sewage loading relationship is the relative effect of detergents as compared to soaps. It might be suspected that the increased quantities of solids and of grease that would apparently be carried over to the absorption field would cause increased soil clogging. However, other factors may be involved, such as the effect of the effluent on soil physical properties and its effect on surface tension, so that the over-all effect of detergents on soil absorption systems cannot be simply deduced.

Similar core studies employing tap water solutions of soap and of detergents, in order to remove the complicating influence of solids, did show differential clogging. In recent exploratory studies at Cincinnati, effluents containing added concentrations of a household detergent and affluents containing added concentrations of household soap appear to have had no different effects on the clogging of laboratory soil cores. The clogging seemed to be *(Continued on page 502)*

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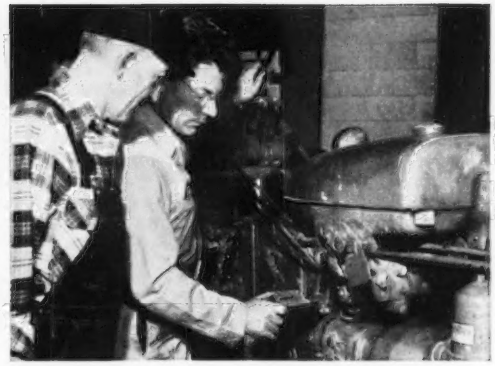

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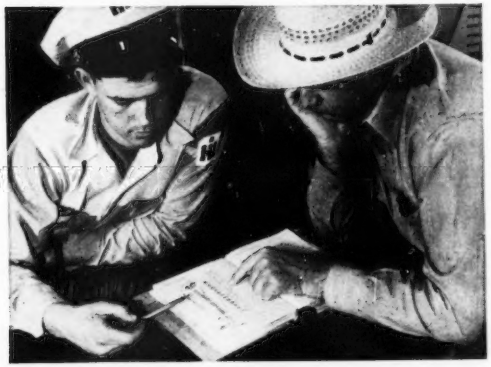

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Effect of Desiccant on Corrosiveness of D-D Mixture

By H. Y. Young, W. A. Gortner and J. F. Cykler
MEMBER ASAE

SINCE the discovery of the potency of D-D mixture (50 per cent 1,2-dichloropropane and 50 per cent 1,3-dichloropropene) as a soil fumigant by Carter*, the pineapple industry in Hawaii has utilized it successfully on a commercial basis with marked beneficial results.

It has been noticed for some time that steel storage drums and stainless steel and brass injection equipment and pumps are subject to corrosion after contact with D-D, especially with lots which have been exposed to the atmosphere. The following tests were therefore made to determine acid content and corrosiveness with particular attention to the effect of moisture and to determine the possibility of control of the corrosive action through use of desiccants.

Table 1 presents results on the acid content of D-D mixture with and without the addition of water after periods of standing in loosely covered flasks at room temperature (27 C).

TABLE 1. ACID CONTENT OF D-D

	Milliequivalents HGl per liter D-D	
Days	D-D	D-D + 1 per cent H_2O
0	2.0	2.0
1	2.3	3.4
4	2.0	2.6
11	1.7	2.4
35	1.7	6.6

Aliquots were extracted with 10 per cent sodium chloride or 10 per cent sodium sulfate and titrated with standard alkali. Acid was definitely present but an increasing gradient of acid concentration up to 35 days was not evident except for the sample to which water was added. For comparison, D-D samples several years old were analyzed and found to contain as much as 27 milliequivalents of acid per liter. The formation of acids in these samples may not be entirely due, however, to the presence of moisture. The possibility that the metal oxides and salts present in storage drums catalyzes the decomposition of the D-D mixture causing an increase in acidity in samples under field conditions was not investigated.

That the acid concentration present, although of a low order of magnitude, is very corrosive to steel particularly in the presence of moisture is demonstrated in Fig. 1. Sections of ½-in steel rods weighing approximately 25 g were placed in flasks containing 250 ml quantities of D-D (Shell Oil Co.) obtained from a newly opened drum, treated with and without 0.25 ml water and 25 g of the desiccant "Drierite," anhydrous calcium sulfate (W. A. Hammond Drierite Co., Xenia, Ohio). The flasks were allowed to stand at room temperature for 24 hr. The removal of traces of water with Drierite apparently effectively prevents the ionization and reaction of the acid present with iron as evidenced by the corrosion-free shiny surfaces of the rods in flasks containing desiccant as shown in Fig. 1. A 7-day period of standing gave similar results. An attempt to evaluate quantitatively the degree of corrosion by determining the loss in weight of the rods was not successful, since this requires the complete removal of iron salts and oxides without removing any of the metal itself. Iron compounds adhering to the metal would increase its weight.

A further corrosion test using varying amounts of Drierite and a period of standing of 7 days showed that with the particular sample tested, the critical quantity of desiccant required to prevent corrosion per liter of D-D was between 5 and 25 g. The former amount resulted in corrosion while the latter did not. (The amount used in the test shown in Fig. 1 was equivalent to 100 g per liter.) It is evident that the amount of desiccant required will depend on the moisture content of the D-D sample.

That the absence of moisture, and not the presence of Drierite, per se, is essential for preventing corrosion was further demonstrated by testing D-D which was dried with Drierite and then decanted. No corrosion on immersed steel rods was noted after a 7-day period of standing. Apparently if D-D is made moisture-free and then kept in air-tight containers, no corrosion should occur.

Silica gel, a commonly used desiccant, was found also to be effective in inhibiting corrosion. However, it is not recommended owing to its catalytic effect on the decomposition of D-D, liberating HCl. HCl fumes and acid condensate on the mouth of the flask were evident.

These preliminary observations are being brought to the attention of workers in the field who may have encountered corrosion problems in the use of D-D, since the data suggest that such corrosion may be minimized by the use of a suitable desiccant in the storage and injection equipment.

Summary. The corrosive effect of D-D soil fumigant (a mixture of 1,2-dichloropropane and 1,3-dichloropropene) on immersed steel rods was found to be completely inhibited by removal of traces of moisture with anhydrous calcium sulfate.

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The authors: H. Y. YOUNG, W. A. GORTNER, and J. F. CYKLER, Pineapple Research Institute of Hawaii, Honolulu, T. H.

*Carter, W.: *Science*, 97, p. 383 (1943).

Fig. 1 The absence of moisture, and not the mere presence of Drierite, is essential for the prevention of corrosion

Septic Tank Disposal Systems

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more related to the amount of suspended solids in the affluent than to the soap or detergent treatments.

The most striking result of the study took place after about 30 days of dosing. At this time, the rates of the detergent cores began to increase and soon reached rates which were faster than the original. During this same period, the soap solution cores continued to clog. On the 55th day of dosing, the treatments were reversed and the clogging trends reversed. The cores then dosed with soap solutions immediately began to clog, and the cores then dosed with detergent solutions showed a tendency for the rates to increase.

The increase in rate of the detergent cores seemed to be associated with the surface tensions of the solutions. When the dosing treatments were added to the cores, their surface tensions were all depressed, compared to water, caused by the surface active material in the soap and in the detergent. After the solutions had passed through the cores, their surface tensions were raised to about that of tap water, indicating that the surface active material was being removed during the percolation. However, when the rates of the detergent cores increased, it was noted that the surface tensions of the percolates were still depressed. The surface active material was evidently no longer being removed, and the reduced surface tension of the solution was effective throughout the core.

We want to emphasize that the results have been obtained under laboratory conditions and with only one soil type. Similar results were not obtained under effluent dosing.

As far as the separation of wastes for disposal in separate lines is concerned, which might be a natural thought, we see no advantage in this at this stage (Continued on page 504)

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Energy Requirement for Shearing Pineapple

By J. F. Cykler
MEMBER ASAE

THE development of a technique for determining basic data on the physical energy necessary to shear pineapple and a mathematical relationship for determining the velocity for free cutting has been completed.

The method used was that of the well-known pendulum-type, simple beam (Charpy), impact-testing machine. This machine measures the energy and not the force required for fracture or cutting. Fig. 1 shows an A-frame built from two-by-four lumber and fastened to a 6-wheel warehouse truck for mobility. A steel pendulum of 0.48 slugs was fabricated and suspended on the crossbeam of the A frame from a shaft supported by pillow-block bearings. A fruit holder was located directly beneath and as close as possible to the center of percussion of the pendulum. To complete the tester, a quadrant and indicating arm was attached to the crossbeam and pendulum shaft. The center of percussion was 32 in from the axis of the shaft. The knife was made from ⅛-in steel. To operate the pendulum, it was rotated to a standard 75-deg angle before being tripped. This gave a maximum swing velocity of 9.4 ft per sec. The initial and final angle of swing was recorded after each trial. The arc-indicating hand was friction loaded and remained on the maximum upswing position.

A series of trials were made on several 3-lb Cayenne variety pineapples to determine the energy necessary to shear a pineapple, to remove the crown at its junction with the fruit, and to remove the crown by lever action on the crown 1¾ in from the junction of the crown with the fruit.

Shearing tests on 14 pineapples show an average energy requirement of 11.4 lb-ft.

Tests to remove pineapple crowns showed that the average energy to cut through the fruit at a junction with the crown is 15.2 lb-ft, and to decrown by knocking off the tops is 12.8 lb-ft.

The energy to shear a pineapple can be calculated from the following equations:

$$FS = W\ (h_1 - h_2) = M/2\ (V_1^2 - V_2^2)\ \text{(foot-pounds)}.$$

A mathematical relationship for determining the knife speed for free cutting involves a few basic equations, namely, $F = M_p A_p$, and these are combined to give a final equation in terms of V_p and Vk, where F = force, in pounds, Mp = mass of pineapple, Ap = acceleration of pineapple due to knife in feet per second per second, Vp = final velocity of pineapple in feet per second, Vk = velocity of knife (constant) in feet per second, S = distance in feet, T = time in seconds, $g = 32.2$ ft per sec^2, and $\frac{1}{2}\ Vp$ = average velocity of pineapples in feet per second. (The pineapple goes from zero velocity to Vp in time T due to the force of the knife.)

Cutting velocity equals $Vc = Vk - Vp/2$, and substituting in $S = VT$ and rearranging in terms of T, gives $T = S \div (Vk - Vp/2)$.

Substituting T in $Vp = Ft \div Mp$, and solving for Vp gives $FS \div Mp\ (Vk - Vp/2)$, and rearranging and solving for Vp gives $Vp = Vk\ (1 - \sqrt{1 - 2FS/MVk^2})$.

In order to solve for Vp a value for Vk must be assumed. The following table solves the above equation, assuming various values for Vk and M:

Vp	Vk	FS	M
2.75 ft/sec	50 ft/sec	13 ft/lb.	0.1 slugs
1.4	100	13	0.1
1.25	50	13	0.2
0.50	100	13	0.2

From this table, it is apparent that as the knife velocity increases the fruit velocity decreases. If practical free cutting is to be used, a small fruit velocity probably would not be objectionable in view of the high knife speeds involved.

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The author: J. F. CYKLER is agricultural engineer, Pineapple Research Institute of Hawaii, Honolulu.

Fig. 1 A-frame, pendulum-type shearing machine for obtaining the energy to shear pineapples

CONCLUSION

1 This experiment gave results for a limited number of fruits tested. However, less energy is required to decrown fruit by pulling out the tops using a lever-type action than any other means tested. An average value of 12.8 lb-ft was required.

2 Slicing a 3-lb fruit required an average of 11.4 lb-ft.

3 A mathematical equation was developed to express free cutting in terms of the fruit and the knife velocities.

Septic Tank Disposal Systems

(Continued from page 502)

of our knowledge. Both field and laboratory studies will be undertaken on this point at the first opportunity.

The alternate or rotational use of tile lines is another question being investigated. A pilot-sized field study indicated that such intermittent use of tile fields may be beneficial, and may prolong the life of an absorption field.

One opportunity for full-scale field study is being provided in Davidson County, Tennessee, by the local health department, where comparable tile lines in a large system are being used under continuous dosing and under alternate dosing conditions. Initial soil tests have been made, and subsequent tests will be made after a change-over in alternate lines.

All of the studies must be considered preliminary, with few definite conclusions reached to date. The results or trends are subject to change or qualification in the light of future developments.

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on mechanical corn pickers—

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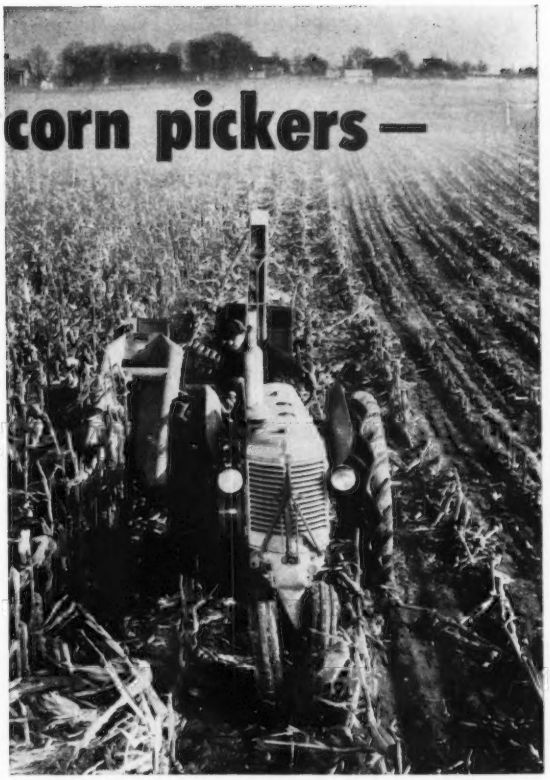

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RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

USDA Agricultural Engineering Research

Drying Corn with Forced Air. Drying corn on the farm with forced-air ventilation is the best way to handle at least a part of the corn crop each fall, according to research of the U.S. Department of Agriculture and a number of state agricultural experiment stations. Several years of accumulated data determined in cooperative studies with the Iowa station, show that forced-air drying offers its greatest advantage in harvesting and conditioning corn without danger of mold, despite the weather.

Mechanical pickers do a better job of harvesting corn, removing more of the husks and leaving less of the corn in the field, when the moisture content of the crop is still high — around 30 per cent, says W. V. Hukill, USDA engineer. Corn is mature before this moisture content is reached. Early harvesting likewise provides better weather, less loss of corn because of insect damage, and in some cases allows the farmer to plow or fall seed the same land.

Harvesting seed corn early reduces the danger of frost damage, which can reduce ability of the seed to germinate and grow.

Satisfactory portable drying equipment and storages designed for forced-air ventilation are becoming available on the market, as continuing research determines the characteristics that make up good drying equipment.

• • •

Transplanting Tung Trees. Much of the hand work of digging and transplanting young tung trees from nursery to orchard can be eliminated with the use of tools and methods developed by USDA research engineer.

Normally the tung trees are dug with a wheel-mounted, U-shaped blade pulled behind a tractor. It is necessary for two men to follow behind the blade to keep it at the proper depth and centered on the row, so that it will cut the tree roots 10 to 12 in below the surface of the ground and about 10 in on both sides of the nursery row. Centering the cutting blade is difficult, especially on contoured fields, because the pruned height of the tung tree (18 in) makes it necessary to drive the tractor so the trees pass under the tractor's rear axle near the wheel, causing sidedraft of the blade.

Agricultural engineer R. E. Jezek, working in cooperation with the Mississippi Agricultural Experiment Station, successfully mounted a similar U-shaped blade on a tractor so that the tractor operator alone could dig the trees. His digger, mounted on the right of the tractor frame, and in front of the operator, reduces labor needs two-thirds and satisfactorily solves the sidedraft problem.

By substituting a 20-in-diameter auger for the ordinary tractor-mounted posthole digger to dig transplant holes in the orchard, Jezek also has cut out more than half the labor needed for hand transplanting. The 4 or 5 in of loose dirt left in the bottom of each hole by the auger and the size of the hole, which allows room for firming the roots by foot, insures each tree getting a good start.

• • •

Brush-type Cotton Harvester. Brush-type strippers may eventually provide the successful answer to low-cost completely mechanical harvesting of cotton in the Southwest, according to W. J. Oates. A harvester of this kind — a new type in the South — is showing considerable promise in current cooperative research at the Oklahoma Agricultural Experiment Station.

The experimental brush stripper substitutes revolving brushes for the fingers or rolls of present day picker-type machine. Because the brushes are pliant, they remove the cotton from the partially dead plants without bits of stem, and at the same time hold any loose cotton that would otherwise fall to the ground.

In comparative tests during the 1949 harvest season, Oates said, the brush stripper harvested more of the cotton than other types of harvesters tested. More important, it did its work without choking or otherwise failing to operate properly. Air was used to move the stripped cotton through conveyor ducts to the trailer where the cotton was collected.

In 1950, after a season of heavy weed growth, heavy boll weevil infestation and a hard freeze killed all the plants before harvest. The brush strippers continued to do excellent work, breaking only small bits of stems from the overly brittle plants, but these were enough to clog the ducts of the pneumatic conveyor system. Commercial machines, operating under the same conditions, pulled stalks and broke stems to such an extent that they made little progress in the field.

This year the engineers are developing a mechanical conveyor system for moving the stripped cotton from the strippers to the trailer, which they believe will work well even under adverse conditions. In addition, they are continuing their research to determine what fibers are best for use in the brushes, and at what speed the brushes should revolve to do their most effective work.

• • •

Automatic Feed Mixer-Grinder. As an aid to busy livestock farmers, engineers of the USDA and the Illinois Agricultural Experiment Station have developed an experimental completely automatic feed grinding and mixing system. Several farm equipment manufacturers, who have been following this research are already working on systems based on the general principles of the experimental setup.

Installed in corn cribs or feed-storage centers, the automatic system removes ear corn, small grain, and protein supplements from storage, feeds them into a grinder in correct proportions, and conveys the blended product to the feed wagon, self-feeder, or prefeeding storage. This system enables a busy farmer to put electric power to one more good use while he is free to do his other chores.

Believing that dependable automatic grinding is most important and high feed output secondary, the engineers settled on a 5-hp, electric hammer mill capable of handling 1,000 to 1,500 lb of ear corn an hour as the most efficient type of unit. Records kept on automatic grinders of these capacities in normal farm use showed that, by freeing the operator to do other work, total automatic grinding costs are well below those of other grinding methods. A 220-v, single-phase, repulsion-induction, high-torque motor has given the most efficient performance; that is, the highest feed output with the least power use.

• • •

Radio Frequency in Grain Conditioning. USDA engineer Finis T. Wratten believes dielectric heating may eventually be useful in drying farm produce to safe storage moisture content because it provides a method of increasing temperatures rapidly and uniformly. He sees further possibilities of radio-frequency heating, in its effect on bacteria, mold spores, nematodes, insects, and enzymes, all present-day storage problems.

In cooperative rice-drying research with the Louisiana Agricultural Experiment Station, Wratten found that satisfactory dielectric drying depended on both temperature and humidity. For example, when the relative humidity of air being forced through the drying grain was less than 50 per cent, temperature of the rice had to be kept under 100 F to prevent damage to its milling quality. When the forced air had a relative humidity between 50 and 70 per cent, temperatures had to be below 105 F.

This past year's results have indicated, too, that short periods of drying with dielectric, followed by a day or longer conditioning period of grain held in storage, produced the best rice-drying rates. Specifically, 10-min applications of heat produced greater drying than longer heating periods, regardless of the length of conditioning-storage time following heating; and a 24-hr conditioning period produced greater drying rates than shorter conditioning periods, regardless of the length of heat application.

USDA engineer Leo Soderholm, who is testing the effect of radio frequency in drying alfalfa hay, corn, and wheat in cooperation with the Nebraska Agricultural Experiment Station, found that drying of alfalfa hay from 80 per cent moisture content to safe storage content was achieved at a fast rate, but costs were high, being practical only if speed of drying were important.

Carotene content of the dielectric dried hay was higher initially than normally dried hay, but loss of carotene after six months seemed to be about the same. With shelled corn, kernel temperatures above 110 F generally damaged germination. One livestock feeding test showed the dielectric drying of corn had little effect on feed quality.

Experiments with wheat indicated that moisture could be removed at a fairly fast rate (from 14 to 4 per cent moisture in 1 min) but the temperature was damaging to germination and baking and milling properties.

• • •

Electric Traps for Tobacco Hornworm Moths. The possibilities of using black-light electric traps to catch tobacco hornworm, night-flying moths in an attempt to thus reduce damage by hornworms in tobacco plantings is being field tested in four southeastern states this summer through cooperative efforts of the USDA state experiment stations, and electric power companies.

Engineers have designed a low-cost, aluminum trap that depends on the light of two 40-w black light lamps reflecting from a painted backboard above the trap. The moths either land on the painted backboard and proceed into the trap or fly directly into the trap. The trap is a simple wire cage into which the moths can readily fly, but from which they cannot escape because of an arrangement of baffles.

Private power companies are cooperating to determine the possibilities of this method of tobacco hornworm control on an area basis. About 40 of these traps are in use at present. Generally four of the traps are installed to cover a square mile of tobacco fields. Although ability of the black-light traps to attract and *(Continued on page 518)*

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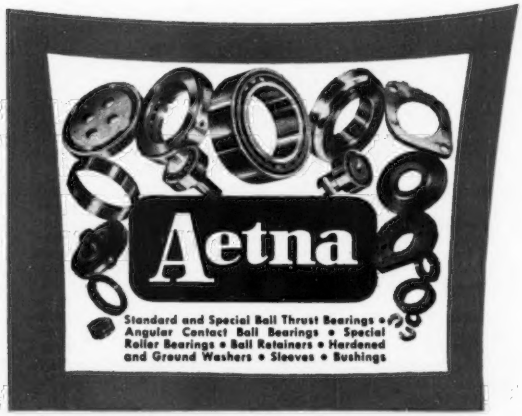
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NEWS SECTION

Pacific Northwest Section to Meet in October

RESEARCH is the phase of agricultural engineering activity to be featured at a meeting of the Pacific Northwest Section of the American Society of Agricultural Engineering at the University of Idaho, Moscow, October 25-27.

Stanley M. Madill, president, ASAE, will address the Section on "New and Better Uses of Materials as Applied to Farm Tractors."

Other guest speakers from outside the Section area are E. A. Juzwik, president, Ezee-Flow Corp. on "Depth Placement of Fertilizer"; D. C. Heitshu, chief engineer, John Deere Harvester Works, on "Engineering Problems in Development, Production, Distribution, and Servicing of a New Farm Machine"; W. Everett Eakin, director of farm research, Libbey-Owens-Ford Glass Co., on "Research in Farm House Heating"; Grant T. Facer, development and engineering division, Kaiser Aluminum and Chemical Sales, Inc., on "Developments in Water-Resistant Outside Materials for Farm Buildings"; and M. R. Lewis, chief, division of irrigation operations, Bureau of Reclamation, on "The ECA Program in Lebanon."

From within its boundaries the Section has scheduled several additional special guest speakers. A welcome to the University of Idaho is to be extended by Rafe Gibbs, director of information for the University. Discussion of the "Drum-Type Hop Drier" will be led by Dr. R. L. Albrook, director of the division of industrial research, Washington State College.

"Lighting Development and Research for Increased Farm Production" is to be reviewed for the Section by W. W. Potter, district engineer, General Electric Co. "Research and Development of Fusing Electrical Circuits" will be reported by A. O. Alderman of the Busman Electric Co. E. E. Johnson, division engineer, Washington Water Power Co., is to summarize "Interesting Developments in Deep Well Pumping for Irrigation."

In the structures field, F. C. Leroux, University of British Columbia, is scheduled for a contribution on "Application of Work Simplification to Farm Dairy Structures."

J. E. Buchanan, president, University of Idaho, is to be the speaker at the Section Dinner, Friday evening, October 26. A. G. Mayer, manager of farm development, Washington Water Power Co., will be toastmaster on that occasion.

Other general program items are to include reports on "Research in Conservation Irrigation," by Wayne D. Criddle, irrigation engineer, U.S. Soil Conservation Service; "Irrigation Research in British Columbia," by J. C. Wilcox, assistant superintendent, Dominion Experimental Station, Summerland, B.C.; and "Effect of Wind on Water Distribution of Sprinklers," by John S. Unbewust, Washington State College.

Registration is to start the evening of October 24, at the Student Union Bldg., University of Idaho. A smoker is scheduled to provide a social evening for those gathering for the early registration.

A business meeting of the Section on Thursday afternoon, October 25, is to be followed by the presentation of student awards papers, reports of ASAE Student Branches in the Section area, and a complimentary dinner for students and faculty advisers. Robert M. Morgan, sales manager, irrigation division, R. M. Wade and Co., will serve as toastmaster at the dinner.

Four concurrent round-table sessions are to be held on Thursday evening.

J. B. Rodgers, head of the agricultural engineering dept., Oregon State College, is to provide over the power and machinery group and call for reports on "Research in Farm Machines" from representatives of research agencies in Oregon, Washington, Idaho and British Columbia.

Sparking the rural electric group from the presiding chair will be Wm. H. Knight, project director, Idaho Farm Electrification Committee. Discussion starters will be reports on "Farm Electric Research and Development," by Frank G. Mackaness, agricultural consultant, Portland General Electric Co.; "Research and Laboratory Work," by Glen Cushing, laboratory supervisor, Puget Sound Power and Light Co.; and "Poultry House Ventilation," by Myron G. Cropsey, associate professor of agricultural engineering, Oregon State College.

Chairman for the soil and water round table will be Walter W. Hinz of Anderson-Miller and Poston Mfg. Co. Discussion of "Sprinkler Irrigation Research Required" is to be led by Max C. Jensen, associate professor of agricultural engineering, University of Idaho. Aldert Molenaar, agricultural engineer, Washington State College, will introduce discussion on "Coordinating the Research Program." "Industry's Part in the Research Program" will be brought up by Marion H. J. Miller, president and production manager, Anderson-Miller and Poston Mfg. Co., and by Robert M. Morgan, manager, irrigation division, R. M. Wade and Co.

"Recent Developments in Farm Home Design" will be the matter for discussion by the farm structures group. Presiding will be G. L. Calver, extension agricultural engineer, University of British Columbia. Scheduled contributors include W. C. Bowen, sales manager, Seifert Lumber Co.; Mr. Ross, head draftsman, Potlatch Yards; Geo. Delany, county agent, Columbia Basin; Frank Webster, county extension agent and Miss Jessie B. Jackson, home demonstration agent, Grant County.

C. J. Hurd, chairman of the Pacific Northwest Section, will preside at the opening of the meeting, the Section business meeting, and the dinner. J. B. Rodgers is to preside during the second half of the opening session.

During the student paper and student branch report session the presiding officer will be Andrew Linn, student vice-chairman of the Section.

Walter Hinz, Fred Johnson and G. L. Calver will carry presiding duties for other parts of the program.

A football game between Washington State College and the University of Oregon is the entertainment offered for Saturday afternoon.

J. W. Martin, head of the agricultural engineering dept., University of Idaho, is in charge of local arrangements for the meeting.

A.S.A.E. Meetings Calendar

October 1—Chicago Section, Agricultural Engineering Bldg., University of Illinois, Urbana.

October 14—WASHINGTON (D.C.) SECTION

October 18 and 19—PENNSYLVANIA SECTION, William Penn Hotel, Pittsburgh, Pa.

October 25-27—PACIFIC NORTHWEST SECTION, Pullman, Wash., and Moscow, Ida.

October 27—OHIO SECTION, Ives Hall, Ohio State University, Columbus

October 30—MINNESOTA SECTION

December 17-19—WINTER MEETING, The Stevens, Chicago, Ill.

February 4-6—SOUTHEAST SECTION, Atlanta Biltmore Hotel, Atlanta, Ga.

June 16-18—ANNUAL MEETING, Hotel Muehlebach, Kansas City, Mo.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

SAE National Tractor Meeting

THROUGH study of present and prospective engineering requirements in the fields of tractors and earth-moving equipment is scheduled for the tractor meeting and production forum to be held by the Society of Automotive Engineers at the Hotel Schroeder in Milwaukee, Wis., September 10-13.

The first day will be devoted to a production forum, with seven separate round-table discussions covering gears, materials handling, quality control, welding, heat-treating, forging, and foundry. Purpose of these sessions is to facilitate exchange of information, with panels of experts answering questions from the floor.

Formal sessions for the presentation of technical papers open Tuesday, September 11, and continue through Wednesday and Thursday. Meeting dinner is to be held Thursday evening, with the guest of honor, J. S. Duncan, of Massey-Harris Co., Ltd., speaking on "Free World at the Crossroads." The SAE Milwaukee Section will hold its annual golf tournament on Friday at Tripoli Country Club.

Technical papers scheduled for presentation cover not only farm and commercial needs for tractors and other heavy equipment, but also the requirements of the military, which has become a large user. Other papers will consider foreign equipment, effects of rim width on tire performance, tractor-ride research, torque-measuring apparatus, and performance characteristics.

New Washington Section Officers

THE Washington, D.C., Section of the American Society of Agricultural Engineers held its final monthly meeting of the 1950-51 meeting season, at the USDA Agricultural Research Center, Beltsville, Maryland, with approximately fifty-five ASAE members and visitors present. One of the features of the meeting was the open house held in the New Farm Electrification Laboratory which featured the activities of the Farm Electrification Division of the USDA.

At the Section's annual business meeting the following officers for the 1951-52 Section year were elected: Chairman, Barton C. Reynolds, agricultural engineer, Office of Experiment Stations, USDA; Vice-chairman, Joseph H. Broome, application's engineer, Government Project's Office, Minneapolis-Honeywell Regulator Co.; and Secretary-Treasurer, Russell E. Uhland, research specialist, Soil Conservation Service, USDA.

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Allis-Chalmers Model D . . . A Natural on Conservation Jobs

Ownership of a *tandem drive* motor grader for building terraces and farm ponds, other dirt handling, is made economically practical for conservation districts, ranches and farm contractors with limited funds.

The Allis-Chalmers Model D has *tandem drive* and other features formerly found only in motor graders costing up to three times as much. Its great traction, convenient size and easy operation make it a "natural" for low-cost terracing work, ditching and farm road maintenance.

Has plenty of power to move big loads fast . . . makes smooth, even grade . . . maneuvers easily. Quickly goes from one job to another — travels up to 18.6 mph.

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Tandem Drive
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Newest, Finest Crawler Tractor Line On Earth — four sizes, 11,250 to 41,000 lb. . . . with matched Allied equipment for every purpose.

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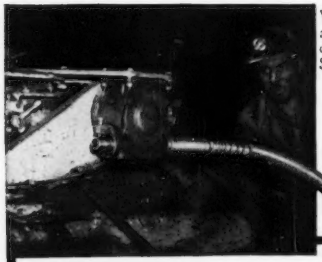

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NEWS SECTION *(Continued from page 508)*

Committee on Professional Registration Reports

ACTIVITIES of the ASAE Committee on Professional Registration reported for the year 1950-51, include the following: (1) Bringing the matter of professional registration to the attention of recent graduates, (2) preparing a set of sample examination questions, and, (3) cooperating with the National Society of Professional Engineers.

The report lists a number of publications on engineering and registration available from the Engineers' Council for Professional Development (29 W. 39th St., New York, N. Y.) and others available from the National Society of Professional Engineers (1121 15th St., N.W., Washington 5, D.C.).

Recommendations for the Committee and the Society for the year 1951-52 are as follows:

1 Prepare and secure material suitable for distributing to agricultural engineering seniors. It appears that the best medium for strengthening the Society from the registration standpoint is through the students.

2 To make available to each agricultural engineering department reports, literature and other data on professional registration which could be used for student and faculty education.

3 Continue contact with the National Council of State Boards of Engineering Examiners.

4 If there is any interest in having sample copies of examination questions the committee should continue with preparing these questions. Also supply answers to many of the questions to serve as a guide while preparing for the examination.

5 Encourage members to take part in the activities of their own state society of professional engineers.

The Committee in its report further suggests that its list of sample examination questions be made available to anyone interested in qualifying for professional registration by examination; that copies of the booklet "Next Step Registration" be sent to every college agricultural engineering department; and that the ASAE give its support to strengthening the "engineer in training" program for preliminary registration of recent graduates in the various states.

Sample examination questions prepared by the Committee are appended to the report.

PERSONALS OF ASAE MEMBERS

Angus Banting, who for several years has been director of agricultural engineering services of the Nova Scotia Department of Agriculture at Truro, recently resigned to accept the chairmanship of the department of agricultural engineering at Macdonald College in Quebec, succeeding L. G. Heimpel who is retiring as department head.

Philip L. Benfield, who recently finished requirements for an MS degree in agricultural engineering at the University of Illinois, has joined the agricultural engineering research staff at Louisiana State University as assistant agricultural engineer.

LeRoy W. Bonnicksen has joined the agricultural engineering staff of Oregon State College, Corvallis, as assistant professor of agricultural engineering and assistant agricultural engineer in the agricultural experiment station. He received his master's degree in agricultural engineering from Iowa State College in June, majoring in the field of farm structures.

Burton S. Horne has resigned as instructor in farm training courses at the Veterans Farm Training Center, Ringtown, Pa., to accept appointment as extension agricultural engineer at Pennsylvania State College.

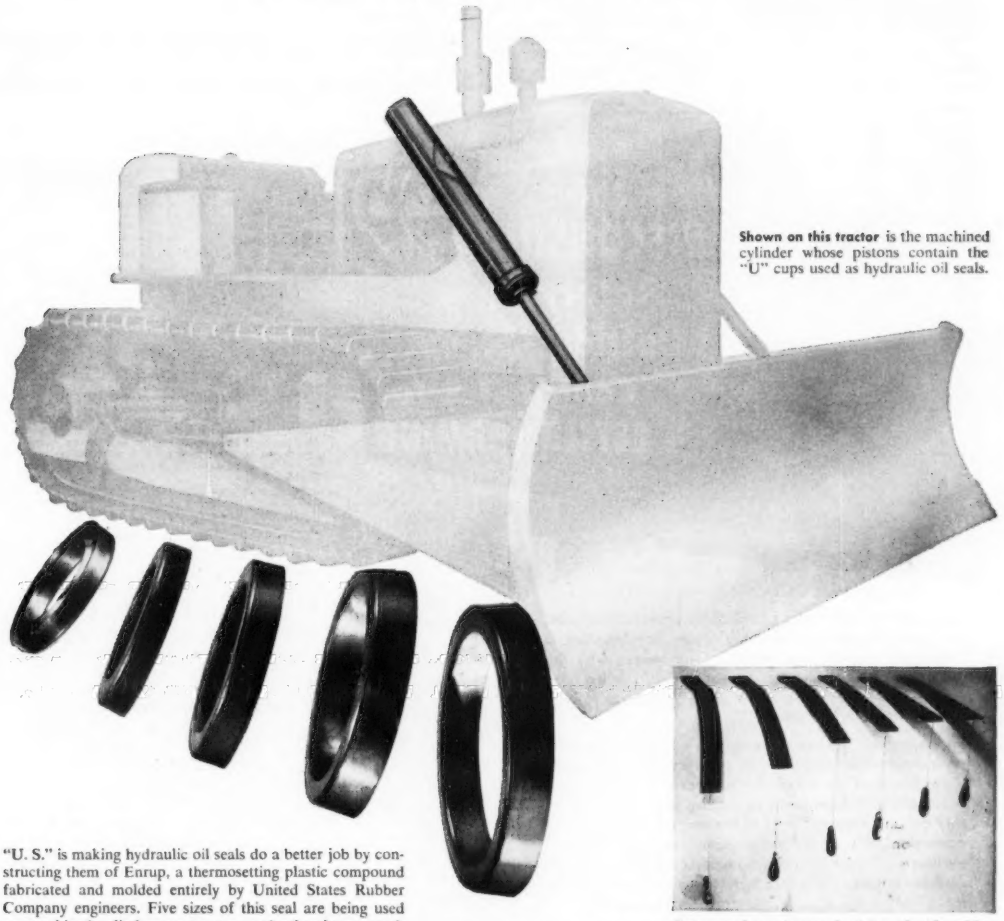
J. C. (Jake) Hundley has resigned as extension agricultural engineer in rural electrification, Tennessee Agricultural Extension Service, to accept appointment as executive manager of the Tennessee Rural Electric Cooperative Assn., 1905 W. End Ave., Nashville, Tenn.

William D. Kenney has accepted the position of design engineer for the Southern Plow Co., Columbus, Ga. He received his B.S. degree in agricultural engineering from the University of Georgia and has been doing research work in peanut mechanization at the Coastal Plain Experiment Station, Tifton, Ga., in a cooperative project between the University of Georgia and the Div. of Farm Machinery, U.S. Department of Agriculture. Mr. Kenney is presently chairman of the Georgia Section of ASAE.

Joseph C. Newell was recently placed on military leave as assistant agricultural engineer in the Louisiana Agricultural Experiment Station to report to Fort Benning, Ga., as an infantry major. He has been assigned to the general staff.

Martin E. Pattyn recently resigned as extension agricultural engineer, University of Kentucky, to accept appointment as sales engineer with New Departure, Div. of General Motors, and has been assigned to the Chicago area. In addition to his work for New Departure he will engage in postgraduate study at the Illinois Institute of Technology.

What's U. S. Rubber doing with hydraulic oil seals?



Shown on this tractor is the machined cylinder whose pistons contain the "U" cups used as hydraulic oil seals.

"U. S." is making hydraulic oil seals do a better job by constructing them of Enrup, a thermosetting plastic compound fabricated and molded entirely by United States Rubber Company engineers. Five sizes of this seal are being used on machined cylinders on tractors and other heavy road-building equipment. These seals last much, much longer than the seals previously used.

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NEW BULLETINS

A Graphic Solution of Agricultural Field Sprayer Problems, by James E. Garton. Miscellaneous Publication No. MP-19 (April, 1951) Oklahoma Agricultural Experiment Station (Stillwater). Simplifies the problem of relating ground speed, nozzle spacing, and discharge per nozzle to desired rate of application.

Nails and Screws in Wood Assembly and Construction, by E. George Stern. Reprint of paper prepared for presentation (May, 1951) before the annual meeting of the Forest Products Research Society, Virginia Polytechnic Institute (Blacksburg) Wood Research Laboratory. This paper, based on an investigation sponsored by the Independent Nail and Packing Co., summarizes information to date on the subject. Plain shank, annular, and screw-threaded shank nails and wood screws are discussed as to design, manufacture and cost, ease of application, and performance in various types of applications. Tables show performance characteristics for a wide variety of combinations of fastener, wood species and load.

Planning Grain Elevators for the Southeast, by W. M. Bruce, W. E. Garner, J. W. Simons, and L. L. Smith. University of Georgia (Athens) Bulletin, Serial No. 1019 (June, 1951). Information on structural, equipment, operating, and other business factors involved in satisfying the growing demand for country grain elevators in the Southeast.

Annual Report of the Director, Experimental Farms Service, 1949-50. Department of Agriculture (Ottawa, Can.) Reprinted from Report of the Minister of Agriculture for the year ending March 31, 1950. Includes brief summary reports of projects considered especially important for the period covered. Those in agricultural engineering include storage of crops, harvesting and tillage for soil erosion (control), rust prevention on tillage equipment, development of a straight blade seeder and a finger weeder, soil conservation studies, barn ventilation, and drainage of marshlands. A special investigation of sprinkler irrigation is also reported.

Barn Hay Driers in Michigan, by W. H. Sheldon, D. E. Wiant, R. W. Kleis, and S. T. Dexter, Michigan State College (East Lansing) Circular Bulletin 219 (June, 1951). Information for farmers on the values of hay drying and on how to plan, install, and operate driers suited to their individual requirements.

Principles of Barn Ventilation, by Wm. Kalbefleisch and J. W. White. Publication 859 (April, 1951) Department of Agriculture (Ottawa, Can.) A nontechnical summary of requirements, influencing factors, natural draft, fan ventilation, and related matters of insulation.

Long-time Tests of Concretes and Mortars Exposed to Sulfate Waters, by Dalton G. Miller and Philip W. Manson. Minnesota Agricultural Experiment Station (St. Paul) Technical Bulletin 194 (May, 1951). Final report of studies on the subject by the Station and the U.S.D.A. from 1919.

(Continued on page 514)

Vital farm power tasks are usually summer-time jobs, but pumping thirst-quenching water for livestock is important summer and winter! One reason why this pump delivers all-season dependability is due to the rotary-type outside magneto of its Wisconsin Heavy-Duty Air-Cooled Engine.

For example, placing the magneto on the *outside* with an independent, direct drive, engine to magneto, provides freedom from ignition troubles. The magneto is a complete, independent operating unit. No need to rely on an unrelated part of the engine for successful operation. It's also tightly sealed against dust and moisture . . . unaffected in summer or winter weather. And an impulse coupling provides a quick, hot spark for all-season easy-starting and steady-running.

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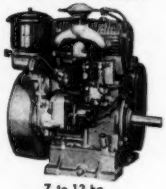
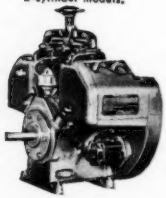

7 to 13 hp. 2-cylinder models.


15 to 30 hp. V-type 4-cylinder models.

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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

ADEE, RAYMOND A., Hutchinson, Kans.

BARRINGTON, GORDON P., Madison, Wis.

BERGSTEN, M. A., East Moline, Ill.

BORNMAN, P. J. U., Barberton, Transvaal, S. Africa

BROWN, KENNETH E., Waterloo, Iowa

BURROUGH, DONALD E., W. Lafayette, Ind.

DIRNBERGER, JOSEPH L., La Lima, Honduras, C. A.

DOOLITTLE, WARREN A., North Platte, Nebr.

DUNNING, JAY J., Springfield, Ohio

GRIFFITH, CLIFFORD J., JR., Dimondale, Mich.

HAGOOD, MELVIN A., Ephrata, Wash.

HEIM, JAMES E., Vandalia, Mo.

HESS, JOHN D., San Diego, Calif.

KNAPP, LAFAYETTE W., JR., Ithaca, N. Y.

KVAMME, ARTHUR E., Minneapolis, Minn.

LANE, ALBERT M., Brookfield, Ill.

LAUDENCIA, PEDRO N., College, Laguna, P. I.

MALWICK, CHARLES S., Racine, Wis.

MEYER, ELDOR W., Girard, Kans.

MYERS, ARTHUR L., Boyertown, Pa.

NIEMAN, MERLE D., New Hartford, Iowa

RUDMAN, CARL, Indianapolis, Ind.

SADLER, LOREN G., Russell, Pa.

SIDES, SAMUEL E., West Allis, Wis.

SPANGLER, PAUL B., Pontiac, Ill.

STOCKING, W. H., Coraopolis, Pa.

STOLTZ, ROBERT W., Ashtabula, Ohio

STROHMAN, ROBERT E., Honolulu, Hawaii

SULLIVAN, ARCHIE W., Lubbock, Tex.

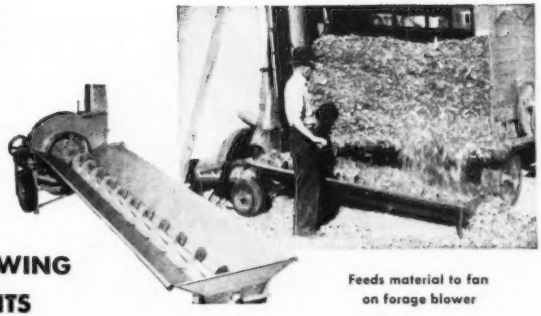
WILKINSON, THOMAS J., Detroit, Mich.

TRANSFERS OF MEMBERSHIP GRADE

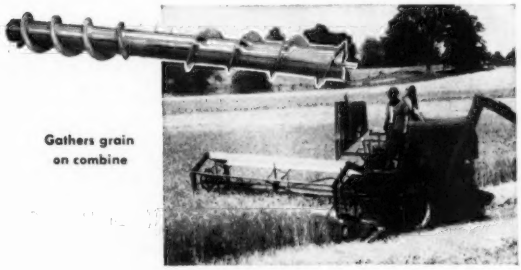
MOWRY, GEORGE R., Alexandria, Va. (From Associate Member to Member)

LINK-BELT SCREW CONVEYOR,

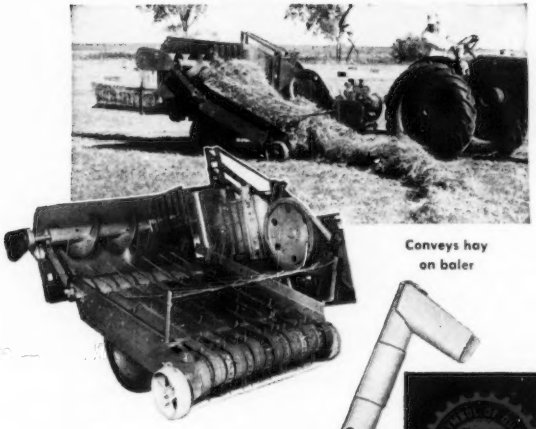
IMPORTANT ELEMENT ON A GROWING LIST OF AGRICULTURAL IMPLEMENTS



Feeds material to fan on forage blower



Gathers grain on combine



Conveys hay on baler

The jobs Link-Belt Screw Conveyor can perform are becoming more and more numerous as engineers utilize its unique qualities . . . simplicity, ruggedness, uniform construction and availability in a wide range of gauges, pitches and diameters. Not only adapted for conventional purposes, these versatile elements are also finding increased usage for boring, elevating, mixing, spreading and feeding applications.

With years of experience and adequate manufacturing facilities, Link-Belt is especially well equipped to supply screw conveyor and flighting, either continuous rolled "Helicoid" or sectional, separately or welded to pipe or shafting as required.

Simple, compact, positive and durable, Link-Belt Screw Conveyors are well suited to many agricultural implement purposes. Link-Belt engineers will gladly cooperate with you in making effective use of screw conveyors in your new designs.

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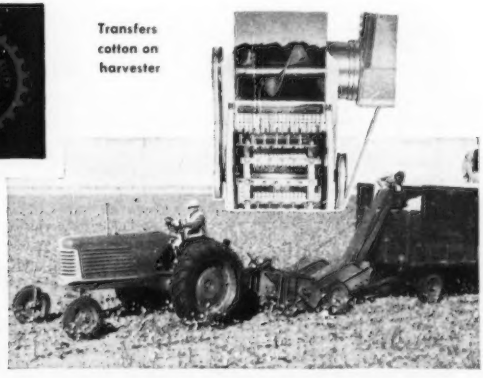
12,214

Elevates feed on grinder



Transfers cotton on harvester

NEW BULLETINS

(Continued from page 512)

Mower Repairs and Adjustments, by W. Kalbfleisch. Publication 746, Department of Agriculture (Ottawa, Can.), reprinted (January, 1951). A brief practical guide for farmers.

Planning an Automatic Water System, by N. H. Wooding, Jr. and D. C. Sprague. Pennsylvania (State College) Agricultural Extension Circular 382 (May, 1951). A guide to farmers on types and capacities to meet their individual farm conditions and requirements.

Fifty Years of Electric Service to the New York Farmer. New York Farm Electrification Council (College of Agriculture, Ithaca, N. Y.). Illustrated narrative summary of progress in rural electrification from a pioneering start in 1900 to present highly developed and profitable farm usage.

Some Notes on the Design, Testing, and Performance of an All-Electric In-Sack Grain Dryer. The British Electrical and Allied Industries Research Association (Thorncroft Manor, Dorking Road, Leatherhead, Surrey, England). Technical Report IB/T5 (1951) 2/6d net. Covers a 1950 experiment in which the demand on an air heater was reduced from 23 kw to 68 per cent of that figure by adjustments in the rate of air flow and other factors.

Electrode Soil Sterilizing, by A. E. Canham. The British Electrical and Allied Industries Research Association (Thorncroft Manor, Dorking Road, Leatherhead, Surrey, England). Technical Report W/T 21 (1951) 9/-net. Preliminary data on current flow and temperature distribution as influenced by moisture content, soil density, and the addition of electrolyte. The study represents one step in an attempt to develop a practical method of sterilizing tomato bed soil in sito using low voltage transformers.

Soil Conservation in New Zealand, by A. P. Grant. Reprinted from the Proceedings (vol. 36, 1950) of the New Zealand Institution of Engineers (Wellington). A discussion of the engineering approach to the problem, with recognition of agricultural considerations.

Computing the Cost of Electrical Service, by G. E. Henderson and C. E. Turner. Southern Association of Agricultural and Vocational Agricultural Educators (University of Georgia, Athens). Bulletin-style instruction material for teaching at the high school level. It covers determining wattage, electrical consumption, and operating cost per month; and approximate wattage, use, and operating cost for individual items of farm and home electrical equipment.

Grading Apples in the Orchard, by H. P. Gaston and J. H. Levin. Michigan Agricultural Experiment Station (East Lansing). Quarterly Bulletin May, 1951, and reprint article 33-41. Reports on a study leading to the conclusion that under conditions existing in many Michigan orchards, a mobile grader will substantially increase net returns.

List of Publications and Motion Picture Films (second edition). Circular No. 3 (October, 1950) St. Anthony Falls Hydraulic Laboratory (Hennepin Island, Minneapolis 14, Minn.) Lists and gives brief information on bulletins, circulars, technical papers, project reports and 16-mm motion picture films which the Laboratory currently has available for distribution.

Use of Models in Planning Water Control Works, by Lorenz G. Straub. Circular No. 4, St. Anthony Falls Hydraulic Laboratory, (Minneapolis 14, Minn.) Copy of a paper presented at the UN Scientific Conference on the Conservation and Utilization of Natural Resources, Lake Success, New York, August 26, 1949. It pictures the concept of the hydraulic laboratory as an adjunct to planning and design, and emphasizes the importance of basic knowledge of fluid mechanics and the mechanics of similitude. Examples of approaches to the experimental analysis of hydraulic structures include several related to soil conservation work.

Research and Facilities, St. Anthony Falls Hydraulic Laboratory. Circular No. 5 (September, 1950) of the Laboratory (Minneapolis 14, Minn.) Presents the nature and operating policy of the Laboratory, description of its facilities, typical research activity, a summary of its current research, and related maps and drawings.

Capacity of Box Inlet Drop Spillways Under Free and Submerged Flow Conditions, by Fred W. Blaisdell and Charles A. Donnelly. Technical Paper No. 7, Series B (January, 1951) St. Anthony Falls Hydraulic Laboratory (Minneapolis 14, Minn.) Both the results presented and the research methods by which they were obtained are of interest in connection with the further improvement and use of this type of spillway in soil conservation measures.

Hydraulic Design of the Box Inlet Drop Spillway, by Fred W. Blaisdell and Charles A. Donnelly. Technical Paper No. 8, Series B (January, 1951) St. Anthony Falls Hydraulic Laboratory (Minneapolis 14, Minn.) This paper is a guide to hydraulic design of this type of spillway and explains briefly the various factors influencing the design. It deals primarily with free flow capacity, outlet design, submerged flow capacity, and utilization of this information in design.

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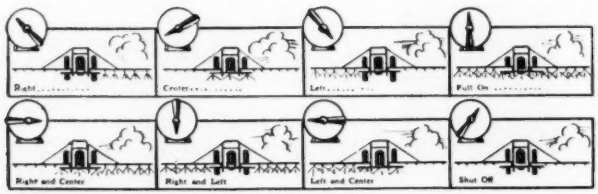

WRITE FOR CATALOG NO. 14

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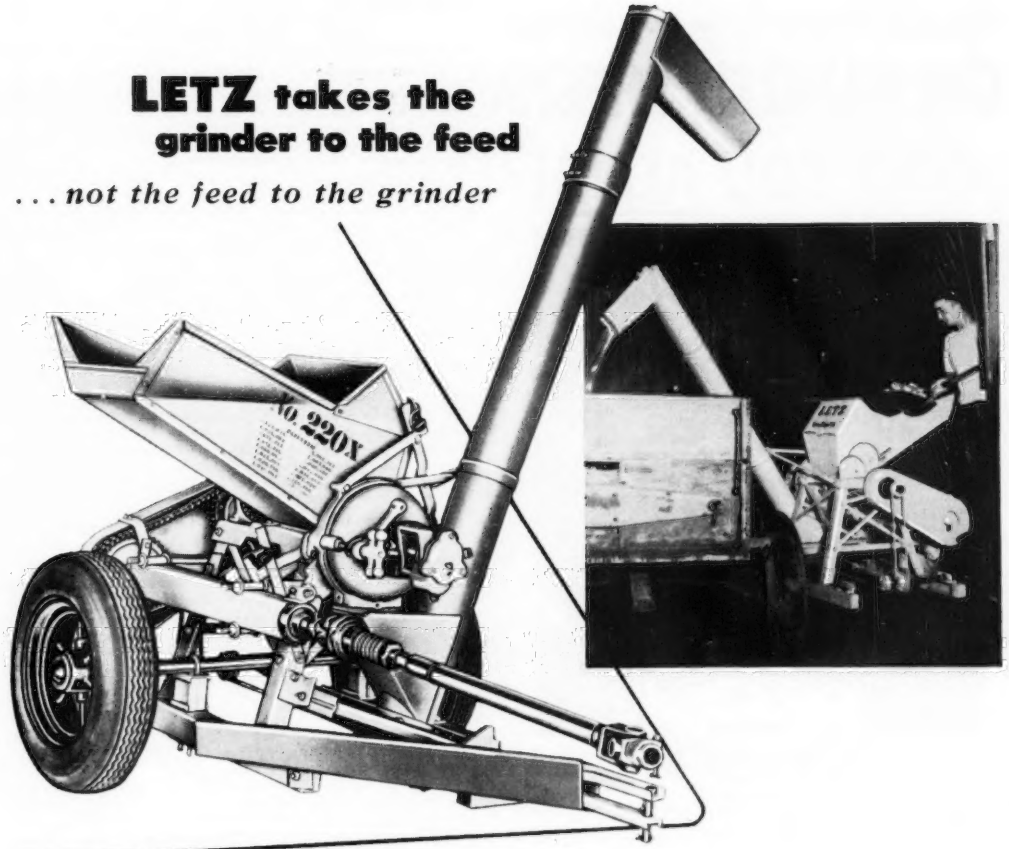

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LAST MINUTE NEWS

Chicago Section Meeting on UI Campus

THE Chicago Section of the American Society of Agricultural Engineers will hold its annual meeting and field day, October 1, on the University of Illinois campus at Urbana. A special coach will be provided for agricultural engineers on Illinois Central train "City of New Orleans" leaving Chicago 7:45 a.m. CST, arriving at Champaign at 9:45. On the return trip, the train will leave Champaign at 4:40 p.m. arriving in Chicago at 8:00 p.m. Special bus transportation will be provided at Urbana-Champaign. There will be special tours of the agricultural engineering building at the University of Illinois and of University Farm with stops at agricultural engineering fields for farm machinery research and at the bin site for building and corn drying research.

A special one and one-half hour program is being arranged covering research activity in agricultural engineering at the University. This will include corn harvester studies; sunflower harvesting equipment; research in tractor valve troubles; corrosion and fertilizer equipment; automatic feed grinding, blending and handling equipment; energy analysis studies of farm chores as affecting farm building design; farmhouse planning research; research in the use of aluminum on the farm; grain storage; tile drainage studies; pasture irrigation, and runoff studies. Members of ASAE who do not receive special reservation cards being mailed to members of the Chicago Section, should write Section Secretary M. L. Burgener, Portland Cement Assn., 33 W. Grand Ave., Chicago 10, Ill., to make reservation for the trip by train.

Ag Engineering Program at Tobacco Workers' Conference

THE second meeting of agricultural engineers working on tobacco production problems will be held at Clemson, S. C., October 9 to 11, in connection with the Tobacco Workers' Conference.

The engineering program this year will feature a panel discussion on mechanizing the harvest of tobacco. This panel will be made up of workers in all phases of tobacco mechanization. In addition a joint session with the agronomy section is being planned featuring irrigation advances in tobacco production. Several interesting phases of curing will also be reported.

A field trip is planned to show some new developments in the handling and curing of Turkish tobacco. There will also be an actual field demonstration of the rotary hoe in the cultivation of tobacco.

The host for the engineering section of the Tobacco Workers' Conference will be the agricultural engineering staff of Clemson College.

All interested persons are cordially invited to attend the Clemson conference, October 9 to 11. A copy of the program may be secured from R. W. Wilson, secretary, agricultural engineering section, Tobacco Workers' Conference, Agricultural Engineering Bldg., Raleigh, N. C. Mr. Wilson will also supply information on room accommodations.

NEW BOOKS

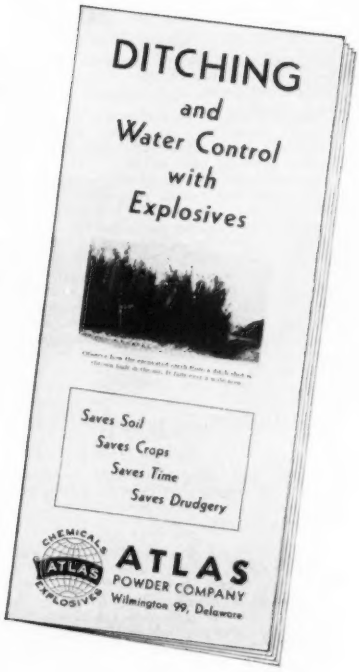
REFRIGERATING DATA BOOK — APPLICATIONS (1950). Cloth, 894+ 224 pages, 6½ x 9 inches. Illustrated and indexed. American Society of Refrigerating Engineers, 40 W. 40th St., New York 18, N. Y. $6.00 in the U.S., $6.60 elsewhere.

This third edition of the "applications" volume of refrigeration data books brings together up-to-date information on applications in eight general fields, including frozen foods, cold storage practice, refrigeration in food manufacture, refrigerated food distribution, low temperature applications, industrial applications of refrigeration, comfort air conditioning, and industrial air conditioning. A section devoted to each of these fields is written and edited by authorities on the subject matter concerned. In all there are 81 chapters. These are supplemented by a classified section showing sources of materials, components, accessories, and complete refrigeration systems.

THE CONSERVATION OF GROUND WATER, by Harold E. Thomas. Cloth, xv + 327 pages, 6 x 9 inches. Indexed. McGraw-Hill Book Co., (330 W. 42nd St., New York 18, N. Y. Also Toronto and London). $5.00.

The Conservation Foundation has sponsored this work, which is subtitled "A Survey of the Present Ground-Water Situation in the United States." It is published in line with the Foundation's purpose to investigate facts and to educate, in recognition of growing water supply problems already experienced by about one-fourth of our population. Chapters cover an introduction, hydrologic principles and basic data, problems resulting from ground-water development and use, groundwater problems resulting from land occupancy, our increasing requirements for water, current deficiencies and future needs for effective ground-water development, and better *(Continued on page 518)*

Here's Where You'll Find The Latest Word



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NEW BOOKS

(Continued from page 516)

ground water management. Appendices cover pumpage from major ground-water reservoirs in order of magnitude, index of localities, and a selected bibliography of aerial ground-water studies.

INSECT CONTROL BY CHEMICALS, by A. W. R. Brown. Cloth, vii + 817 pages, 5½ x 8½ inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.; London: Chapman and Hall, Ltd.) $12.50.

Thorough coverage of a rapidly developing field will make this an important and highly useful reference on the subject to persons interested from any of several angles. Of particular interest to agricultural engineers is the fact that the author has included chapters on equipment developed for the application of insecticides and the application of insecticides from aircraft. Other chapters deal with insecticides of the midtwentieth century and their properties, the structure of organic chemicals and their toxicity to insects, susceptibility of insects to the entry of poisons, the pharmacology of poisons for insects, toxicity and hazards to man and domestic animals, toxicity of insecticides to plant growth, chemical control of insects feeding on plants, chemical control of insects affecting man and animals, and insecticides and the balance of animal populations. Each chapter is followed by an extensive list of references cited, some 2300 in all. This provides a highly classified bibliography on the various phases of the subject.

RESEARCH NOTES

(Continued from page 506)

catch moths of the tobacco hornworms was shown in experiments during 1950, the engineers say extensive field tests are essential to determine whether such traps can provide a practical answer to control these pests in specific tobacco fields.

• • •

California Cotton Research Needs. Satisfactory weed control was named by research engineers of the U.S. Cotton Field Station, Shafter, Calif., as the biggest drawback to complete mechanization of cotton production in that state's high producing San Joaquin Valley. J. R. Tavernetti, California Agricultural Experiment Station, and B. B. Ewing, USDA, believe that the rapid expansion of use of mechanical pickers to harvest cotton has accentuated the need of research to bring cultural practices up to the mechanical level of harvesting. About half of California's estimated 1¼ million cotton acres will be harvested with some 3,000 mechanical pickers this year.

Here is the way engineers size up current weed-control possibilities:

1 Pre-emergence chemical weed control shows little promise in California, despite encouraging results in other areas. Use of chemical sprays after the cotton is up may be practical, but more study is needed on their application and effectiveness.

2 No one type of mechanical cultivator proved better than another, but the use of special equipment after the normal cotton "lay-by" period, did provide promising control of late weeds. By modifying a high-clearance picker-tractor and shielding its wheels to prevent damage to the cotton plants, the engineers were able to control weeds for a month after the time normal mechanical cultivation stopped.

3 Flame weeding, in combination with mechanical cultivation, shows considerable promise, and may become a common practice in California's cotton fields.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: NOVEMBER—O-102-510. DECEMBER—O-113-514. 1951—APRIL—O-226-525. JULY—O-299-527, 301-529, 305-531. AUGUST—O-282-532, 320-533

POSITIONS WANTED: NOVEMBER—W-99-18. 1951—JANUARY—145-27. FEBRUARY—W-164-35. MARCH—W-120-37, 172-39, 185-42. APRIL—W-202-46, 212-48. MAY—W-252-53, 253-54, 276-56, 277-57. JUNE—W-264-58, 260-59, 232-60, 261-62, 280-63, 263-65. JULY—W-205-66. AUGUST—W-310-69, 315-70, 292-71

NEW POSITIONS OPEN

CHIEF AGRICULTURAL ENGINEER for design and development of new products and improvement of current products of a farm equipment manufacturer in the East. BS deg in agricultural engineering or equivalent. Five years or more of experience in design and development of new mechanical products. Prefer man who is presently an assistant chief or chief engineer. Normal good character and business references. Right man would become part of top level management with opportunity of participating in profits of company. Company is growing steadily. Age 35 or over. Salary open. O-330-534

AGRICULTURAL ENGINEER (assistant) for research in all branches of the field, in a state agricultural experiment station in the South. MS deg in agricultural engineering, or equivalent. Good opportunity for advancement. Salary $4,000-$4,800. O-340-539

AGRICULTURAL ENGINEER for staff of operating division of a large canning company in the Midwest. Maintenance of field machinery, including viners and other specialized pea and corn machines. Also assisting in testing, selection, and development of new machines, development of existing maintenance organization, control of expenditures for field machines, and planning field work methods. BS deg in agricultural engineering, or equivalent and 3 yr experience in general farm power and machinery work, including work management and supervision of personnel. Must be able to work with people effectively and be a capable instructor. Ingenuity, initiative, good judgment, and good health required. Must have car. Work requires frequent travel within a radius of 100 miles. Good opportunity for advancement. Age 25-30. Salary $4,000-$5,300. O-353-540

DESIGN ENGINEER for development work on tillage, planting, and cultivating implements with a large farm equipment manufacturer in the Midwest. BS deg in agricultural or mechanical engineering. Two or more years experience on implement design or similar work. Farm background and usual personal qualifications for commercial design. Salary open. O-354-541

AGRICULTURAL ENGINEER for agricultural extension work as a rural electrification specialist in two North Central states. BS deg in agricultural engineering and special interest in rural electrification. Farm background. Previous agricultural extension experience or farmer contacts and public meeting experience. Usual personal qualifications for extension work. Good opportunity for advancement. Age 25-35. Salary $3,800-$4,400 and expense account. O-355-542 *(Continued on page 520)*

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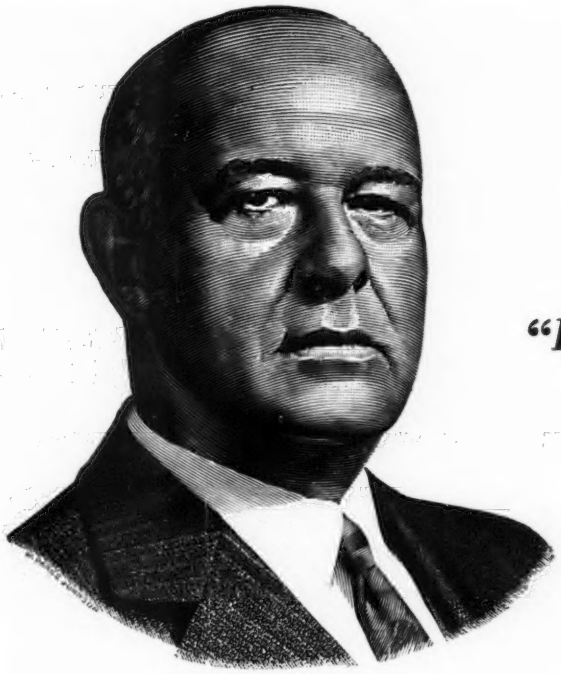

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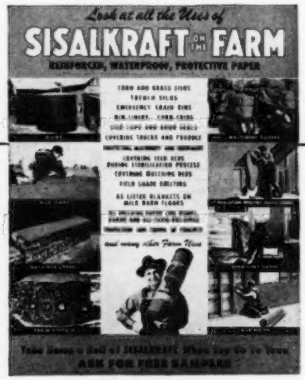

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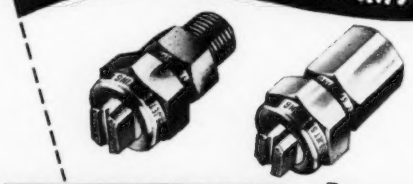

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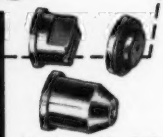

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 518)

FARM MACHINERY ENGINEERS, designers (all grades), draftsmen and field test men for positions in an expanding organization that we are not able to fill by promotion of present staff. Progressive organization with ideal engineering facilities and air-conditioned offices; located at edge of small city in beautiful Lancaster County, Pennsylvania. Only men with excellent character and clean living habits desired. Excellent opportunity for professional development and advancement. Salaries commensurate with background, experience and ability. O-356-543

NEW POSITIONS WANTED

SALES, service, management, or export manager for Europe with manufacturer of farm equipment, preferably in Midwest or West. MS deg in mechanical engineering, 1932, University of Stuttgart, Germany. Executive positions in European farm machinery industry, 1932 to 47. Since 1947, project and research engineer with a manufacturer of mechanical equipment in the U.S.A. Married. Age 44. No disability. Available October 1. Salary $8,000-$10,000. W-331-72

DESIGN, development, or research in the power and machinery or soil and water field, in industry or public service. BS deg in agricultural engineering, 1949, University of Tennessee. Farm background. State department of agriculture 10 mo. Manager of nursery 1½ yr. Married. Available on reasonable notice. Salary $300 mo. W-333-73

EXTENSION, teaching, or service in power and machinery field with college or manufacturer, west of Mississippi River and east of Rockies. BS deg in agricultural engineering 1950, Kansas State College. Farm background, including work with many kinds of farm machinery. Photo technician in Army one year. Soil Conservation Service, U.S.D.A., since graduation. GS-7 rating. Design and layout of mechanical conservation measures. Married. Age 25. No disability. Available on reasonable notice. Salary $3,600. W-334-74

Resistance of Grains to Air Flow

(Continued from page 495)

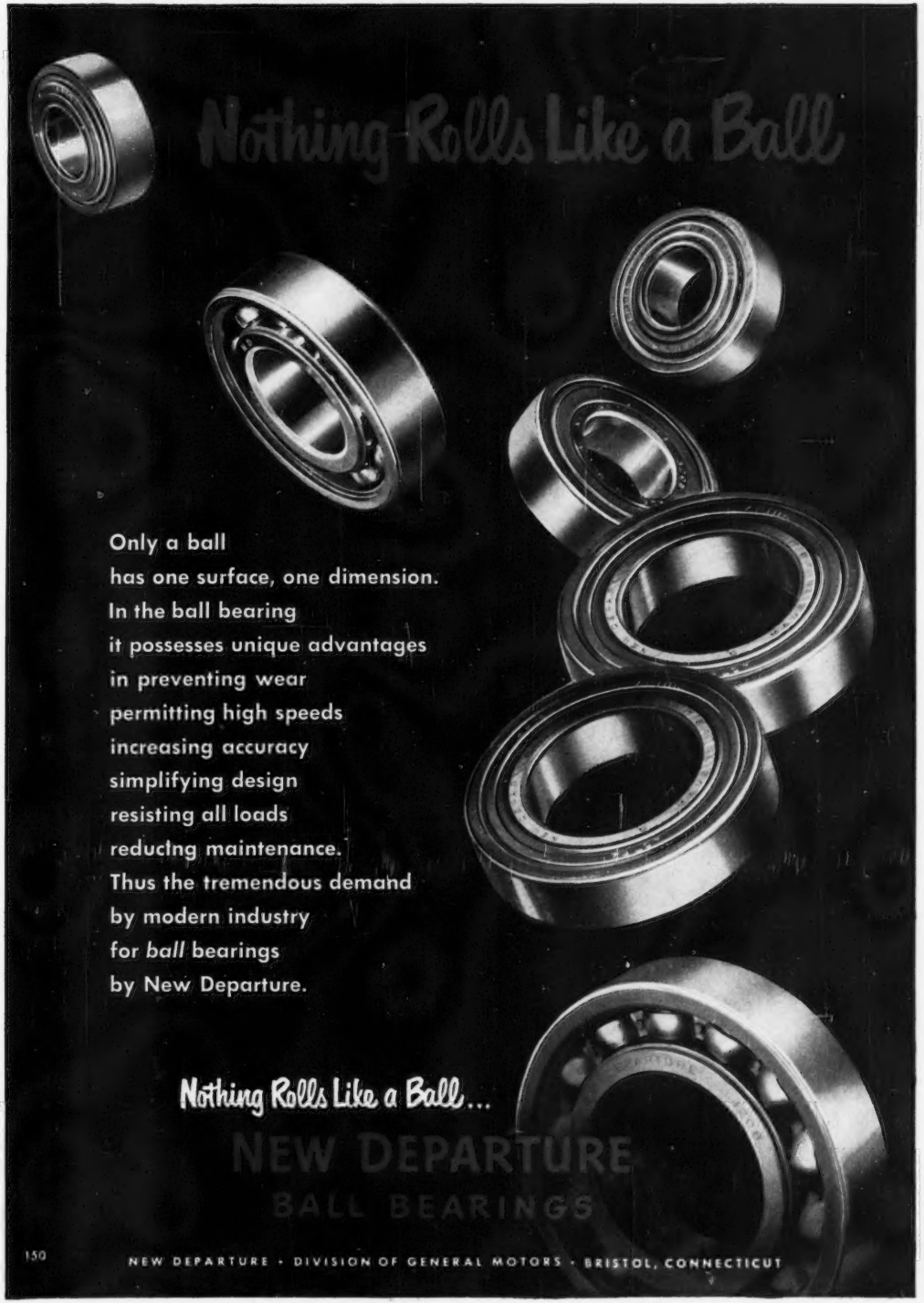
Moisture content of grain was an important factor. Damp grain did not pack as tightly as dry grain and the resistance to air flow was less with the damp grain. For example, referring to Table 2, corn lot 3a was the same grain as lot 3 but with moisture content increased from 12.8 to 20.0 per cent. The resistance pressure of lot 3a (20 per cent moisture) was only 0.56/0.89, or 63 per cent of the resistance pressure of lot 3 (12.8 per cent moisture).

The method of filling a bin has a large influence on resistance to air flow. The largest difference between loose and packed fill in these tests was with corn lot 3d, dry corn containing 5 per cent cracked grain and foreign material. With this lot, the resistance pressure with packed fill was 60 per cent greater than with loose fill. The smallest difference was with lot 3a, clean corn containing 20 per cent moisture. With this lot, the resistance pressure with packed fill was only 20 per cent greater than with loose fill.

The presence of 2 per cent screenings caused only about 16 per cent increase in resistance pressure, but 5 per cent screenings caused an increase of 46 per cent comparing loose fills, or 70 per cent comparing packed fills.

It seems probable that there may be a good deal of variation in the rate of air flow through different parts of the mass of grain in a bin that is filled in the ordinary way. At the point where the elevator spout discharges the grain, the grain would be most densely packed and would contain the largest proportion of cracked grain and foreign material. It may be expected that air movement will tend to by-pass this area.

In a batch-drying operation, a favorable factor would be that the grain shrinks first at the bottom of the bin as it dries. This would cause the grain to be less densely packed after drying has started than at the beginning of the drying operation.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In the ball bearing
it possesses unique advantages
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permitting high speeds
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simplifying design
resisting all loads
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Thus the tremendous demand
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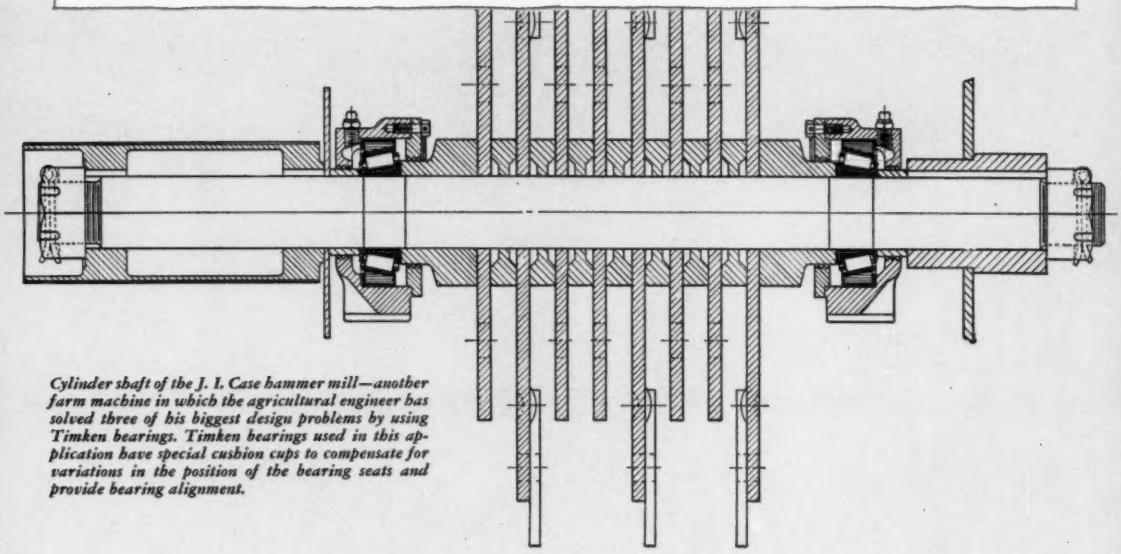
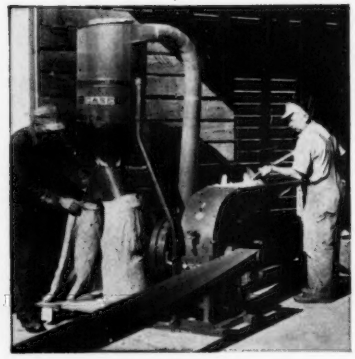
EVERY NEW FARM TRACTOR HAS TIMKEN BEARINGS...
MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!



Cylinder shaft of the J. I. Case hammer mill—another farm machine in which the agricultural engineer has solved three of his biggest design problems by using Timken bearings. Timken bearings used in this application have special cushion cups to compensate for variations in the position of the bearing seats and provide bearing alignment.

How TIMKEN® bearings help Case hammer mill do bang-up job



HERE'S what J. I. Case engineers gained by mounting the cylinder shaft of this hammer mill on Timken® bearings:

Timken bearings take both radial and thrust loads so there's minimum deflection and end-play. Special cushion cups provide bearing alignment despite variation in the position of the bearing seats. Due to true rolling motion and smooth surface finish, Timken bearings practically eliminate friction, make parts rotate freely. And Timken bearings keep lubricant in, dirt out.

This illustrates how, with Timken bearings, you can solve three of your biggest problems at once—(1) combination loads, (2) ease of operation, (3) dirt. And at the same time you insure the farmer of these five extra advantages when he buys: (1) longer implement life, (2) easier operation, (3) less chance of breakdown on the job, (4) once-a-season lubrication, (5) higher speeds.

For information on Timken bearing applications in farm machinery, write today for your copy of "Tapered Roller Bearing Practice on Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

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